BIOLOGY OF THE MEMBRACIDAE OF THE CAYUGA LAKE BASIN

A THESIS

Presented to the Faculty of the Graduate School of Cornell University for the Degree of

DOCTOR OF PHILOSOPHY

BY

WILLIAM DELBERT FUNKHOUSER

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BIOLOGY OF THE MEMBRACIDAE OF THE CAYUGA LAKE BASIN

W. D. Funkhouser

The purpose of this study is to summarize the work of seven years, in field and laboratory, on the biology of the species of Membracidae found in the Cayuga Lake Basin and particularly in the vicinity of Ithaca, New York. Sixty-one species of this family of Homoptera have been reported from the basin. A few of these are very rare and are known only from occasional records of the past twenty years. Most of them, however, have been recognized, and parts, if not all, of their life histories determined. The life cycles of the majority of the local forms have been worked out in detail and in a few cases the results of the work have been published. Since the life histories of the closely related forms agree in many respects, the separate discussion of each species would result in a multiplication of details, and therefore an attempt is made in this report to incorporate the data in such form as to give a general idea of the whole subject, omitting unnecessary repetition, condensing the facts common to all forms, tabulating whenever possible the data showing fluctuation and variation, and paying special attention to peculiar or unique phenomena.

The membracid fauna in the immediate vicinity of Ithaca has been rather thoroly studied. During certain seasons daily field notes have been made for periods of from six to eight consecutive weeks, and careful records kept of climatic and seasonal conditions with respect to their bearing on the ecological problems involved.

The fauna of the other parts of the valley has not been so well worked out, but large quantities of material from various stations have made it possible for the investigator to form a fairly accurate idea of the membracid representatives in the basin as a whole. That part of the basin at the northern extremity of the lake is the least known, as it has not been possible to do extensive collecting in that region. There is no reason for believing that the area offers any particular problems or differs in any important respect from the remainder of the valley, but recent botanical

collections from parts of the district have yielded such distinct floral specimens that it seems probable that new species of Membracidae may be found there on further search.

Naturally a number of problems remain unsolved. These can be worked out only by experiments and observations extending over a series of years. It is hoped that the present report may suggest such problems and stimulate an interest in their solution.

Acknowledgment is made to Professors O. A. Johannsen, W. A. Riley, and J. C. Bradley, of the Department of Entomology at Cornell University, under whose direction the work has been done and whose kindly criticisms and suggestions have been most appreciated.

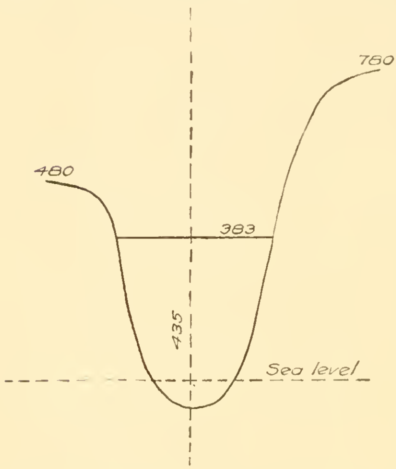

FIG. 34. CROSS SECTION OF CAYUGA LAKE

GEOGRAPHY AND PHYSIOGRAPHY OF THE CAYUGA LAKE BASIN

Cayuga Lake is the largest of the five so-called "Finger Lakes" of central New York. It is about forty miles in length and varies from one and one-half to three miles in width. The average depth is approximately four hundred feet, and the banks slope sharply to the center in a pronounced V (fig. 34). On either side of the lake the hills rise to an average height of from four hundred to six hundred feet, continuing the V, as seen in the figure, about as high above the water line as the distance below it. These hills are cut by narrow gorges thru which flow small streams with very picturesque falls and rapids. The surface of the lake is about three hundred and eighty-five feet above sea level, the bottom therefore being lower than sea level at mean tide.

A number of small tributaries flow into the lake near its head (fig. 35). The most important of these are: Cayuga Inlet (the old Neguæna Creek), extending almost directly southward; Six Mile Creek, extending southeastward; Cascadilla Creek, extending due eastward; Fall Creek, extending northeastward from the head of the lake; Taughannock Creek, on the

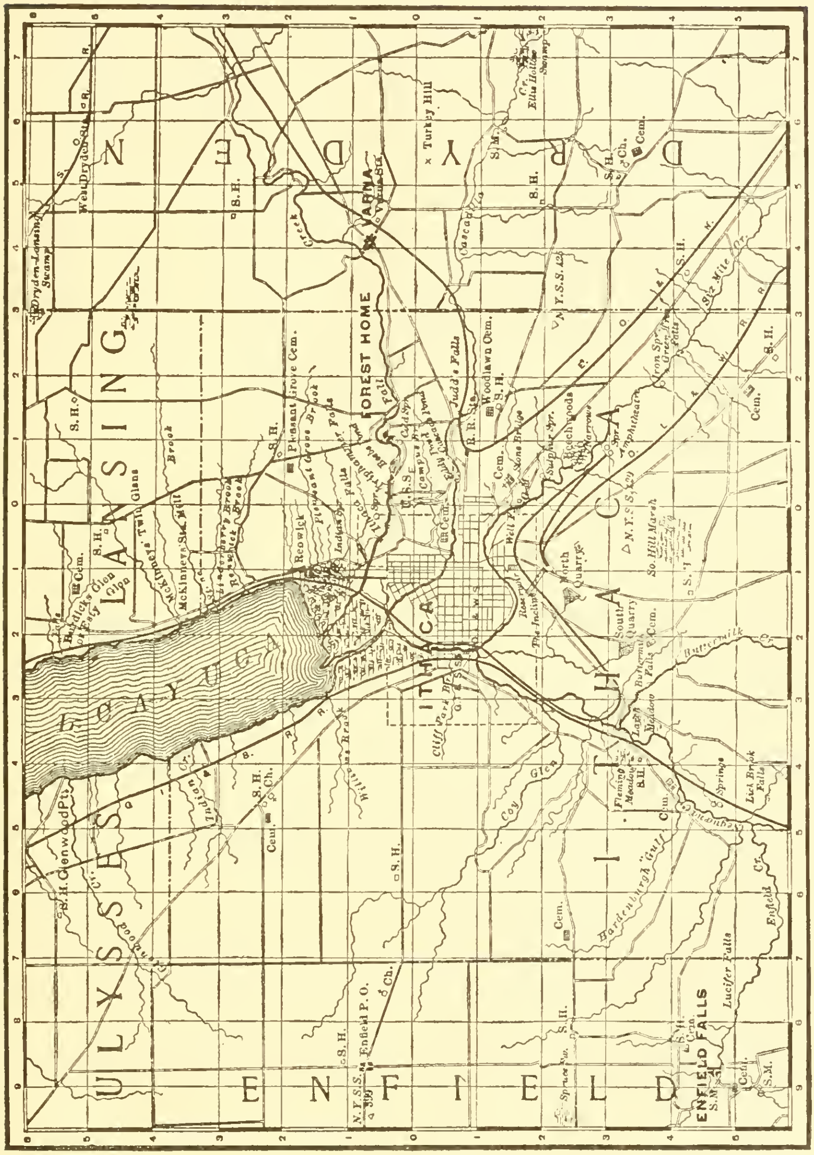

FIG. 35. MAP OF THE REGION ABOUT ITHACA, SHOWING THE SOUTHERN TRIBUTARIES OF CAYUGA LAKE

west side, flowing northeastward and emptying into the lake below Taughannock Falls; and Salmon Creek, on the east side, flowing southwestward and joining the lake just below the village of Ludlowville. All of these creeks are small and comparatively shallow, but the drainage area which they represent is considerable, including nearly two thousand square miles.

The actual catch basin is narrow at the northern end and wide at the southern, as shown in figure 36. This figure is taken from Reed and Wright (1909)[1], and is admirably suited to the needs of this study since it has been carefully compiled with special reference to faunal distribution. The basin is about sixty-five miles in length, and varies in width from about eight miles at the northern end of the lake to nearly thirty miles at its widest southern part, where the extension of Fall Creek gives an additional drainage area to the northeast. At its northern extremity the basin gradually merges into the flat plain which extends to Lake Ontario.

In the valley proper the elevation averages about four hundred feet above sea level. The surrounding hills rise from two hundred to one thousand feet, with occasional higher elevations such as Connecticut Hill (2095 feet), South Hill (1732 feet), and Turkey Hill (1460 feet), which are more or less mountainous in character; all of these are included in this report as part of the basin.

Geologically the lake is believed to have been a preglacial river channel which was deepened and widened by glacial action. The terminal moraine extends irregularly south of the basin. The tributaries flowing into the lake from the east and from the west have cut narrow postglacial gorges into the lake valley. The gorges are generally clean-cut, with precipitous sides, and descend abruptly toward the lake, the fall in the last mile often being three or four hundred feet. Commenting on this fact, Dudley (1886:x) states:

> The true gorges are probably without exception, of recent or post-glacial origin, the walls are frequently of perpendicular or overhanging rock from fifty to two hundred feet, or even much higher, as in Taughannock and Enfield ravines. Within these great chasms are usually falls or cascades, some of them exceedingly beautiful and of considerable height.

The physiography of the entire region is extremely rugged and irregular (fig. 37), and affords some of the most picturesque scenery to be found in the State.

[1] Dates in parenthesis refer to bibliography, pages 433–445.

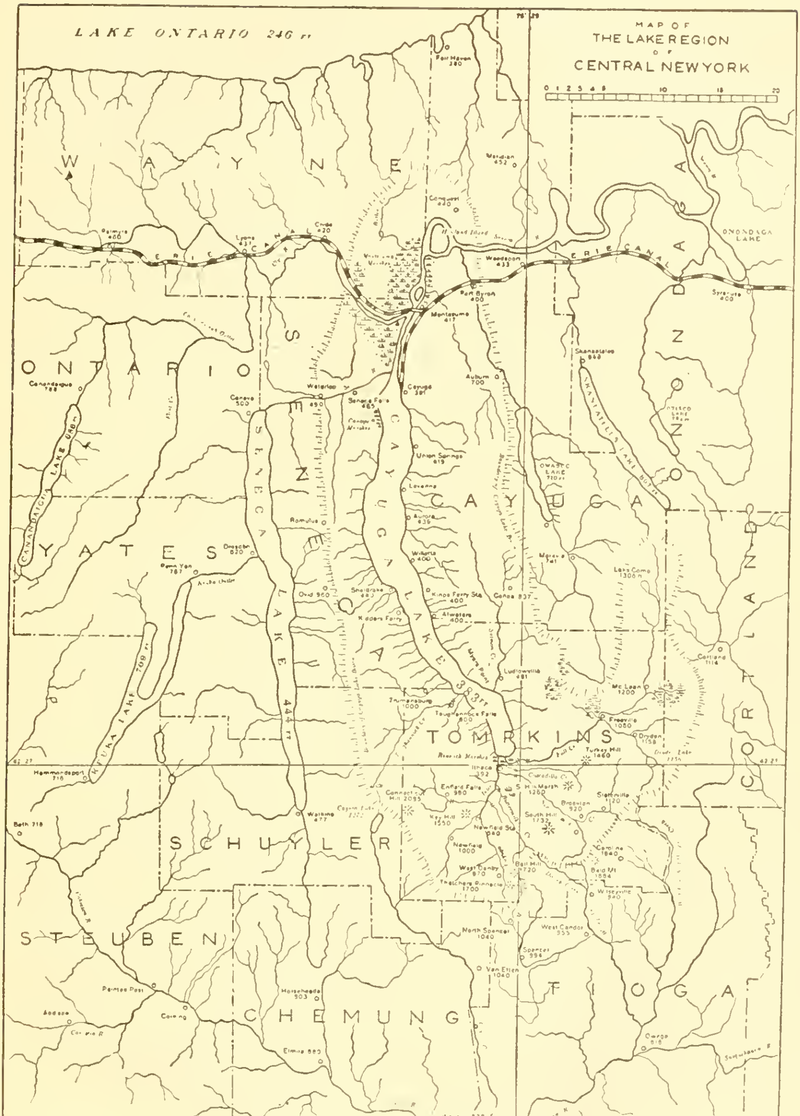

FIG. 36. MAP OF "FINGER LAKE" REGION OF CENTRAL NEW YORK, WITH CAYUGA LAKE SHOWN IN DETAIL

The approximate drainage basin of Cayuga Lake is indicated by the broken line
(Reproduced by courtesy of Dr. A. H. Wright)

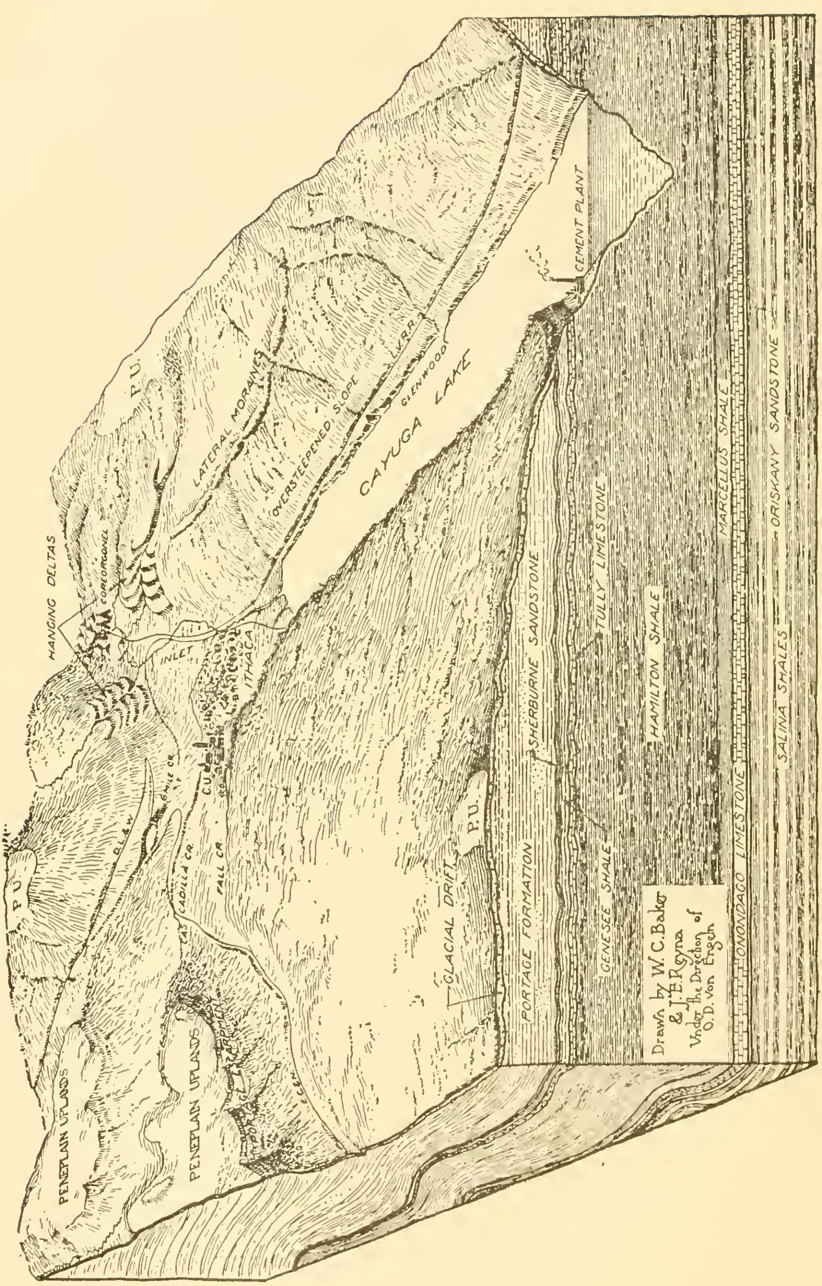

FIG. 37. RELIEF MAP OF PART OF THE ITHACA REGION, SHOWING PHYSIOGRAPHICAL NATURE OF THE BASIN
(Reproduced by courtesy of Professor O. D. von Engeln)

CLIMATOLOGY OF THE BASIN

The climate of the Cayuga Lake basin is undoubtedly influenced, and to some degree regulated, by the water of the lake. Because of its depth the lake water remains cold until late in the summer, and retains the summer heat to such an extent that the surface is rarely entirely frozen over. In fact a tradition to the effect that the lake freezes over once in every twenty years has been noted by Dudley (1886: vii) and by Reed and Wright (1909: 372), and is verified in a general way by the records of the local weather bureau. Reasonably reliable data tend to show that the lake was entirely frozen over in the winters of 1796, 1816, 1836, 1856, 1875, 1884, and 1904. There is also a tradition, persistently advocated by many of the older inhabitants, to the effect that there is an underground connection betwen Cayuga and Seneca Lakes. Usually at least two-thirds of Cayuga Lake is open thruout the winter; the shallow water at either end freezes over about the last of December and remains frozen until about the first of March.

The effect of this on the plant life of the basin has been noted by Dudley as follows (1886: vii):

> The temperature of the lake unquestionably influences the development of vegetation in its immediate vicinity. Plants on its shoies are usually a week later in the Spring than in the neighboring ravines and the warm valley about Ithaca, and a week earlier than on the distant highest hills; and during the first half of November, the blue flowers of *Aster lævis* and the white plumes of *Aster sagithfolius*[2] still remain in considerable abundance, while they have long ago matured and faded near Ithaca.

It will be seen that a similar condition has been found in regard to the insects treated in this study, largely due no doubt to the condition of the host plants on which they live.

The natural influence of the lake on the surrounding temperature, which affects the floral and the faunal forms, has been explained by Von Engeln (1914: 347) as follows:

> Where bodies of water of considerable area exist they exert an important equalizing effect on temperature. Water absorbs more heat, holds more heat, is warmed to greater depths, absorbs and radiates heat more slowly than land. Further, 50 per cent of the insolation on water areas is used in evaporating water. This develops a moist blanket of air above and adjacent to the water surfaces that is less subject to marked temperature fluctuations than dry air. The total effect of these differences is to make summers cooler, winters warmer, to prolong the fall season and retard spring, and, also, to check sudden temperature changes in short time periods.

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[2] So in original. Doubtless *Aster sagittifolius*.

It has been observed by agriculturists, tho thus far without explanation, that there is a difference in the condition of crops and fruits on the two sides of the lake. This has been found true also in the life histories of the membracids, the forms on the west side of the lake being later in appearance and slower in development than those on the east side. But, as in the case of the plants, no reason for this difference is forthcoming. Whether such variation has been observed for any other insects is not known.

The climate thruout the basin is variable, showing rather extreme ranges in temperature thruout the year; and, owing partly to differences in elevation and partly to protection from or exposure to winds, some sections of the area under consideration are quite different in climate from others. The territory represented by the eastern and the southern hills is notably colder than the sheltered stations in the valley, and these regions have a much greater snowfall. The western and the northern stations are, on the other hand, warmer and show less snow and less intensity of winds.

The city of Ithaca, at the head of the lake, may be taken as giving a fair average for the basin. The temperatures for this station are shown in the following table, which has been compiled from figures extending over the last thirty-five years:

TEMPERATURES AT ITHACA (DEGREES FAHRENHEIT)

	Highest	Mean	Lowest
January	70°	24°	—20°
February	62°	25°	—18°
March	82°	32°	—14°
April	87°	44°	13°
May	96°	57°	22°
June	96°	66°	32°
July	102°	71°	40°
August	98°	68°	39°
September	96°	61°	29°
October	87°	50°	17°
November	75°	38°	— 1°
December	65°	28°	—20°
Annual	102°	47°	—20°

For the period represented in the table, the following temperature data, valuable for consideration in ecological studies, may be noted:

Mean annual	47°
January average	24°
July average	71°

Highest, 102°, July 4, 1911
Lowest, —20°, December 20, 1884, and January 19, 1904
Most days with temperature of 90° or above in one month, ten, in July, 1911
Most days with temperature of 0 or below in one month, twelve, in February, 1885
Warmest month, July, 1887, average 74.8°
Coldest month, February, 1885, average 15.3°

Second only in importance to the question of temperature in the study of biologic conditions in insects, is that of precipitation. This average for Ithaca is as follows:

AVERAGE PRECIPITATION AT ITHACA (INCHES)

January	2.16	July	3.75
February	1.87	August	3.24
March	2.44	September	2.83
April	2.29	October	3.17
May	3.43	November	2.58
June	3.88	December	2.64
Annual	34.28		

Of particular interest in this study has been the rainfall during the summer months of the last five years. This is as follows:

RAINFALL AT ITHACA IN SUMMER (INCHES)

	1912	1913	1914	1915	1916
April	2.97	1.49	4.35	0.55	2.77
May	3.58	3.15	3.63	2.44	4.27
June	1.37	2.00	4.75	3.94	3.48
July	2.64	1.59	1.89	6.18	1.29
August	3.54	1.92	6.10	3.70	1.50
September	7.46	3.28	1.96	2.58	5.65
October	1.86	3.63	1.38	4.10	1.59

The bearing of these data on the ecological studies of the Membracidae will be discussed later, but it may be noted here that during this period

some extremes occurred which offered excellent opportunity for observations in the field. The summer of 1913, for example, was unusually dry. Concerning this drought the United States Weather Bureau reports:[3]

The drought of 1913 was remarkable both in its duration and in the time of its occurrence, covering nearly three months and extending well over the maturing period of important crops. It began to retard the growth of vegetation quite generally by the second week in June, and, in spite of occasional rains, became almost gradually worse until the 22d or 23d of August, when heavy rains brought decided relief in most parts of the State. In some sections, however, the drought remained unbroken until in September — so late that no amount of rainfall could bring the stunted crops to maturity.

In many sections of the State pastures failed completely and cattle and horses had to be fed full winter rations for several weeks. Almost the entire State suffered some loss in pastures and more or less reduction in the yield in staple crops, particularly of those that mature in the latter part of the season, such as corn, buckwheat, pears, apples, peaches, and fall potatoes. In many localities one or more crops were reported as being practically failures. In some of the central and eastern counties the water supply was so reduced that it became difficult to secure enough for the most urgent needs in cities and villages, the use of water for sprinkling lawns and flushing streets having been discontinued, while farmers in many places were obliged to haul water from a distance, as most wells, springs, and creeks were dry. A number of correspondents report that wells and streams became dry that were never before known to fail.

An examination of the precipitation record shows that a remarkable deficiency in rainfall was experienced in most parts of the State.

The average precipitation in the basin is slightly less than that for the stations just outside of the basin, with the exception of the city of Binghamton. Like the temperature record, the precipitation record shows some interesting extremes and variations, among which are the following:

Mean annual precipitation, 34 inches
Average number of days with 0.01 inch or more, 155 in a year
Heaviest rainfall in twenty-four hours, 4.16 inches, September 10, 1890
Most rainfall in one week, 5.56 inches, September 8–13, 1890
Most rainfall in one month, 8.14 inches, August, 1885
Least rainfall in one month, 0.3 inch, May, 1903, and March, 1910
Driest summer (June, July, and August), 1910, 5.15 inches
Wettest summer, 1892, 17.04 inches

In the report of the local weather bureau for September, 1914,[4] is found an interesting table giving the amount of rainfall at excessive rates during the last fifteen years. The dates noted which appear in the course of this study are the following:

One inch or more an hour, 1.09, June 28, 1914
1.08, August 20, 1914
Most in five minutes, 0.47, June 28, 1914
Most in ten minutes, 0.92, June 28, 1914
Most in fifteen minutes, 1.05, June 28, 1914

[3] U. S. Weather Bureau. Monthly weather review 41:1133. 1913.
[4] Climatic summary for Ithaca, New York, with comparative data for other places in New York and near-by States. U. S. Weather Bureau, Ithaca, New York. September, 1914.

It will be noted that the summer of 1914, besides showing extremes of sudden rainfalls, had a heavy average precipitation. The effect of this on the life histories of certain Membracidae has been noted (Funkhouser, 1915f:191), and a comparison of the summers of 1913 and 1914 in the effect on the insects in general is shown in a later table in this paper (page 411).

The snowfall in the basin is not excessive but shows considerable variation. This, however, affects the biology of the insects under consideration only in a slight degree, and only those forms that hibernate in the earth during the winter. The climatological data on this point are given in the local weather bureau report already cited (footnote 4) as follows:

AVERAGE MONTHLY SNOWFALL AT ITHACA (INCHES)

January	13	May	between 0.1 and 0.5
February	12	October	between 0.1 and 0.5
March	10	November	5
April	4	December	11
Annual			56

Most snowfall in one winter, 79 inches, 1910–11
Least in one winter, 28 inches, 1912–13
Most in a month, 45 inches, December, 1902
Least in a winter month, 2 inches, January, 1913
Latest in spring, May 28, 1902
Earliest in fall, September 30, 1889

More important than the snowfall is the question of the date of killing frosts in spring and in autumn. A comparison of these dates with those of the appearance and the disappearance of certain Membracidae has proved extremely interesting. Fortunately the records of frosts have been carefully kept at the local weather bureau, and a valuable report has been made on the subject.[5] This report gives the following data for the city of Ithaca, which, while not applicable to the entire basin, is general enough to be of practical value:

Average date of last killing frost in spring, May 4
Average date of first killing frost in fall, October 10
Number of days between these dates, 159

[5] Wilson, Wilford M. Frosts in New York. Cornell Univ. Agr. Exp. Sta. Bul. 316:505–568. 1912.

The latest recorded killing frost in spring for the basin was on June 9, 1913; the earliest recorded killing frost in fall was on September 14, 1911.

Reports on relative humidity are not available in a form applicable to this study, but it is believed that this subject is of much importance in its reference to the hatching of eggs and the development of nymphs. The following figures, covering a period of three years, give the averages for the basin:

Average annual humidity, 70 per cent
January average, 79 per cent
July average, 68 per cent

These figures, however, would be valuable only in comparing life histories of insects in the basin with those of other localities. For the purpose of comparing the development of the membracids, it would of course be necessary to have weekly, or at least monthly, reports for a series of years and similar biologic reports on the insects.

Bearing more closely on the subject of insect habits is the question of sunshine, and this applies to a large extent to the family in question since the Membracidae are sun-loving forms and their feeding habits depend largely on this feature of the local climatology. In this connection the following table for the Cayuga Lake Basin may be of interest:

Average Sunshine (in Per Cent of the Possible)

January	28	July	64
February	44	August	61
March	44	September	58
April	48	October	44
May	55	November	29
June	61	December	23
Annual	47		

It will be noted that the region is, on the whole, more or less gloomy, and the physiography of the basin, with the deep gorges and the dark ravines, exaggerates this to some extent; so that individual stations, limited in area, would perhaps show a still greater lack of sunshine.

THE BASIN AS A FLORAL AND A FAUNAL AREA

The Cayuga Lake Basin represents the Transition Zone in its flora and fauna. Reed and Wright (1909:376) have recorded all of the nine species

of mammals which Miller (1899) designates as serving to identify any part of the Transition Zone in New York.

Eastern, Canadian, Upper Austral, and Lower Austral forms are represented among the birds recorded for the basin, and in a number of cases the species representing these zones breed in the locality. The fishes show traces of Lake Ontario fauna with occasional representatives of Susquehanna Valley and Erie Basin forms. The amphibia are largely southern and the reptiles very meager. (Reed and Wright, 1909:384–385.)

In the same manner the flora of the region shows traces of widely scattered forms, and among the rarer plants occur some that bear the stamp of remote geographical nativity (Dudley, 1886:vii). The peat bogs in the vicinity of Freeville, the marshes at the foot of the lake, and the more secluded parts of the ravines, show forms of plant life which are without doubt migrants from distant floral areas, and their mode of introduction into the basin is unknown.

In this connection it should be noted that the Cayuga Lake Basin is intimately connected with the Susquehanna River on the south and the Ontario plains on the north. Wilseyville Creek, which flows down into the Susquehanna Valley, is at one point only about half a mile from Six Mile Creek, which flows into Cayuga Lake, and it is probable that at flood times the sources of these creeks are connected. The inlet of Cayuga Lake, likewise, rises at about a mile from Spencer Creek, which flows to the Susquehanna Basin, and at the same elevation. In the same connection it should be remembered that the region at the foot of the lake gradually opens into the Ontario flats without geographical or faunal barriers.

It is to be expected that the insect fauna would show similar transitional forms, as is indeed the case. Little literature is available relative to the distribution of special groups of insects in the basin, but in many instances records show the presence of Canadian, Southern, and Western species. It will be shown in the course of this study that the Membracidae list is representative of a wide range of distribution.

On the other hand, the basin is in some respects cut off from the surrounding territory. It will be noted that a few species described with the basin as a type locality have never been recorded from any other part of the State. Conversely, species that are abundant in neighboring counties are seldom recorded locally. The latter condition is illustrated in the Membracidae in the cases of *Publilia concava* and *Micrutalis calva*.

The most important papers relative to the basin as a faunal and a floral area, and indeed the only ones in which the subject is discussed with direct application to the local physiography, are those already mentioned — the work by Dudley (1886) and that by Reed and Wright (1909). Of these the former is the more valuable in connection with the study of phytophagous insects, since it offers valuable data concerning the distribution of the plant forms that serve as hosts.

The distribution of the Membracidae according to the range of their host plants is noticeable to a marked degree thruout the State. Professor W. L. Bray, of Syracuse University, has made a careful study of the floral regions in New York State, and has shown that the areas as outlined in this study for insects agree with the zonal distribution of plants. He states (Bray, 1915:59–60):

> The study of certain features of the dissected highlands — deeply cut valleys and the slope and exposure of their adjacent sides — yields instructive data as to the distribution of floristic elements.
>
> In general the dissection of the plateaus by north-south drainage channels leads to a northerly extension of austral species.................... This northerly extension appears to be especially marked in the region where the long, deep valleys of the Cayuga and Seneca lake basins continue the dissection across the plateau into the Ontario basin.

There seems to be no doubt that this is the case in the region under consideration, and it is likely that the migration of certain plant species has had much to do with the distribution of the insect forms that feed on these plants or are limited to particular plant hosts for their oviposition.

CHECK LIST OF GENERA AND SPECIES

The following species of Membracidae have been recorded for the Cayuga Lake Basin:

Centrotinae:

1. *Microcentrus caryae* Fitch (p. 209)

Membracinae:

2. *Campylenchia latipes* Say (p. 212)
3. *Enchenopa binotata* Say (p. 214)

Smiliinae:

4. *Ceresa diceros* Say (p. 218)
5. *Ceresa bubalus* Fabr. (p. 219)
6. *Ceresa taurina* Fitch (p. 225)
7. *Ceresa constans* Walk. (p. 227)

Smiliinae (continued):

8. *Ceresa Palmeri* VanD. (p. 230)
9. *Ceresa borealis* Fairm. (p. 231)
10. *Ceresa basalis* Walk. (p. 232)
11. *Stictocephala inermis* Fabr. (p. 233)
12. *Stictocephala lutea* Walk. (p. 235)
13. *Acutalis tartarea* Say (p. 237)
14. *Micrutalis dorsalis* Fitch (p. 237)
15. *Micrutalis calva* Say (p. 238)
16. *Carynota mera* Say (p. 239)
17. *Carynota porphyrea* Fairm. (p. 243)
18. *Thelia bimaculata* Fabr. (p. 243)
19. *Glossonotus acuminatus* Fabr. (p. 245)
20. *Glossonotus univittatus* Harris (p. 246)
21. *Glossonotus crataegi* Fitch (p. 247)
22. *Heliria scalaris* Fairm. (p. 248)
23. *Telamona declivata* VanD. (p. 250)
24. *Telamona pyramidata* Uhler (p. 251)
25. *Telamona barbata* VanD. (p. 251)
26. *Telamona obsoleta* Ball (p. 252)
27. *Telamona Westcotti* Godg. (p. 253)
28. *Telamona reclivata* Fitch (p. 253)
29. *Telamona monticola* Fabr. (p. 256)
30. *Telamona querci* Fitch (p. 257)
31. *Telamona ampelopsidis* Harris (p. 258)
32. *Telamona tristis* Fitch (p. 260)
33. *Telamona concava* Fitch (p. 261)
34. *Telamona projecta* Butler (p. 261)
35. *Telamona unicolor* Fitch (p. 262)
36. *Telamona pruinosa* Ball (p. 263)
37. *Telamona decorata* Ball (p. 264)
38. *Archasia Belfragei* Stål (p. 265)
39. *Smilia camelus* Fabr. (p. 266)
40. *Cyrtolobus ovatus* VanD. (p. 268)
41. *Cyrtolobus fuliginosus* Emm. (p. 268)
42. *Cyrtolobus muticus* Fabr. (p. 269)
43. *Cyrtolobus tuberosus* Fairm. (p. 272)
44. *Cyrtolobus discoidalis* Emm. (p. 272)

Smiliinae (concluded):

45. *Cyrtolobus cinctus* VanD. (p. 273)
46. *Cyrtolobus vau* Say (p. 274)
47. *Cyrtolobus intermedius* Emm. (p. 275)
48. *Cyrtolobus cinereus* Emm. (p. 276)
49. *Cyrtolobus fuscipennis* VanD. (p. 276)
50. *Atymna castaneae* Fitch (p. 277)
51. *Atymna querci* Fitch (p. 279)
52. *Atymna inornata* Say (p. 280)
53. *Xantholobus trilineatus* Say (p. 281)
54. *Xantholobus lateralis* VanD. (p. 281)
55. *Ophiderma salamandra* Fairm. (p. 284)
56. *Ophiderma pubescens* Emm. (p. 285)
57. *Ophiderma flavicephala* Godg. (p. 286)
58. *Ophiderma flava* Godg. (p. 286)
59. *Vanduzea arquata* Say (p. 287)
60. *Entylia bactriana* Germ. (p. 289)
61. *Publilia concava* Say (p. 291)

One or two of the above are known only from single specimens taken a number of years ago and never recorded since, but they are included so that the list may be entirely complete. The original records are doubtless authentic and the specimens are in the Cornell University collection.

DISTRIBUTION AND RANGE OF THE FAMILY

The representatives of the Membracidae have not been taken uniformly thruout the basin and are much more numerous in some localities than in others. They are more abundant on the east side of the lake than on the west, and far more plentiful in the southern part of the valley than in the northern. This is due chiefly to the fact that the areas in question are not uniformly wooded with plants which are favored by membracids as hosts, and the fact that geographical conditions, and variations in amount of heat and of sunlight, are not the same in all localities. The species of Membracidae are sun-loving insects, and, as will be shown, are quite susceptible to environmental conditions. Moreover they are very dependent on particular food-plants and seldom if ever change their hosts.

Certain areas thruout the basin have been arbitrarily designated as *stations* (fig. 38). These are in some cases rather indefinitely bounded,

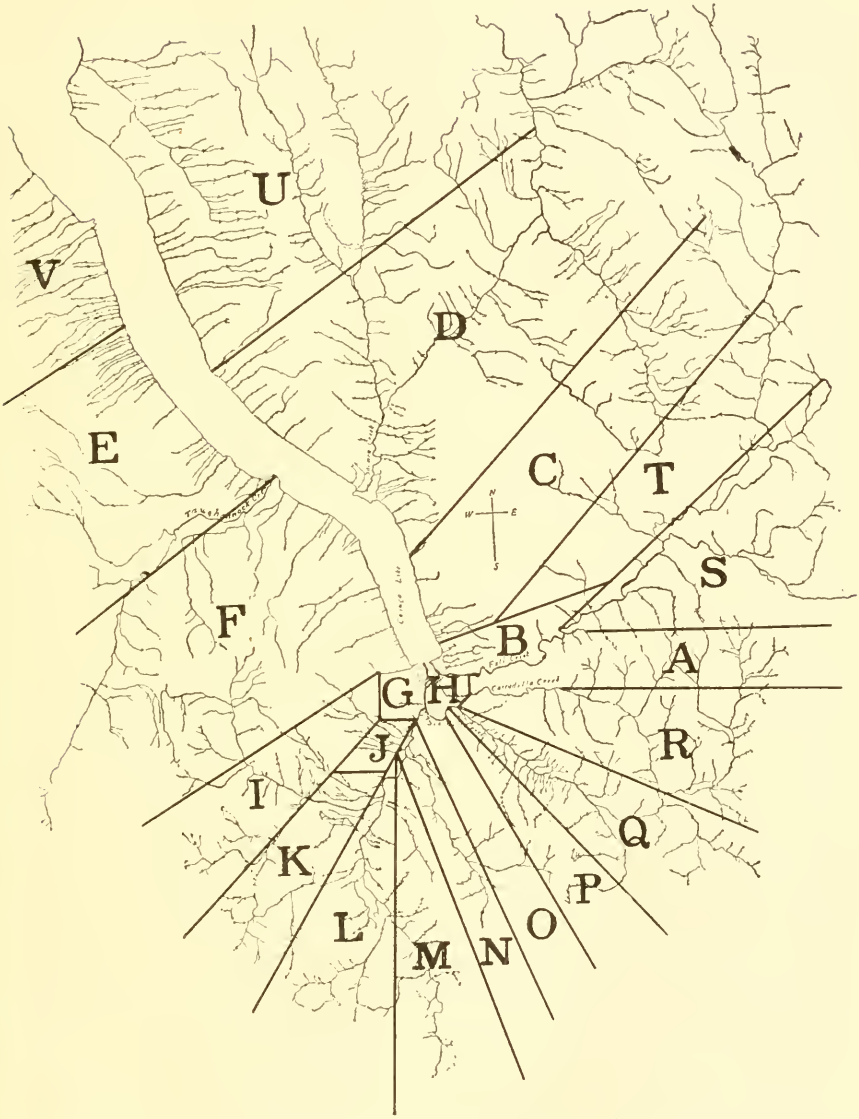


Fig. 38. drainage map of cayuga lake region showing location and extent of the various stations discussed

The watershed areas are as follows: Fall Creek, 117 square miles; Cascadilla Creek, 16.2 square miles; Six Mile Creek, 46.4 square miles; Inlet, 92.9 square miles. The check marks across the streams indicate successive elevations (contour intervals) of 20 feet each

(Reproduced by courtesy of Professor J. G. Needham)

but they generally represent more or less distinct physiographical regions. For the sake of convenience these areas will be referred to in the course of this report by the following letters:

Station A, that part of East Hill in the city of Ithaca east of Linn Street, including the old city cemetery and the steep banks west of the gun works, the university campus, and the territory directly eastward. Part of this area is thickly covered with small locust trees, and in and around the cemetery and the campus are a considerable number of cultivated shrubs. This is an excellent station and from it have been collected large numbers of *Thelia bimaculata, Vanduzea arquata, Enchenopa binotata*, most species of the genus Ceresa, and occasionally *Archasia Belfragei, Smilia camelus*, and *Stictocephala lutea*.

Station B, the hills east of Renwick and southeastward to Cornell and Cayuga Heights. These hills are densely wooded near the lake and more open eastward. The wooded parts contain principally locust and oak. The open spots, particularly the abandoned street-railway road, are overgrown with sweet clover and goldenrod. Along the roadsides considerable black elder occurs. This is one of the richest stations in the basin, and yields *Ceresa diceros, Vanduzea arquata, Thelia bimaculata, Enchenopa binotata*, and a number of species of Cyrtolobus, especially *C. vau*, in great abundance.

Station C, the hills on the east side of the lake extending from McKinneys to Portland. Scattered woods, cultivated fields, pastures, and neglected roadsides make up this station. The section supports hickory, pignut, maples, and small oaks, scattered growths of blackberry and raspberry, and some cultivated fruits. It is a good station for various species of Ophiderma and one or two of the rarer forms of Ceresa.

Station D, the region around Rogues Harbor and northward. This section consists of rolling farm lands, orchards, and pastures. Fruit trees have yielded considerable membracid material, and during certain seasons timothy, clover, alfalfa, and buckwheat fields have proved good collecting grounds. Scattered areas of goldenrod, New England aster, joe-pye weed, and sweet clover are found along roadsides and fences. In this station have been collected a large number of the local species of the genus Telamona, and most of the grass-inhabiting forms such as *Stictocephala inermis, Campylenchia latipes*, and *Ceresa bubalus*.

Station E, the hills west of the lake between Trumansburg and Interlaken and including these two villages. The country is principally given over to farm lands and is rich in cultivated fruits, particularly apple, pear, and cherry. Considerable timothy and buckwheat is grown. Around the farmhouses and buildings is a great deal of woodbine. *Ceresa taurina*, *Ceresa bubalus*, *Stictocephala inermis*, *Stictocephala lutea*, *Enchenopa binotata*, and *Telamona ampelopsidis* are common in this station.

Station F, the region west of the lake between Trumansburg and the Lehigh Valley railroad station in Ithaca. This station contains a variety of physiographical conditions and a varied flora. The farms south of Trumansburg are rich in fruit; the hills sloping to the lake are densely wooded with second-growth trees — chestnut, maple, oak, and birch — with much underbrush; the roadsides and the railroad tracks have growths of woodbine, bittersweet, and sweet clover; the flats south of the lake and west of the inlet are low and wet, being chiefly filled-in marshland and covered with cat-tails, red elder, and water plants. The station has proved a poor one for Membracidae but has occasionally yielded *Atymna castaneae* and *Enchenopa binotata*.

Station G, the Renwick woods and flats south of the lake and west of the inlet. The flora of this region is extremely varied. There are a large number of old trees of many species, and the section is rich in shrubs. Poison ivy and woodbine are plentiful. Asters, joe-pye weed, and giant ragweed are hosts for certain Membracidae. The most abundant species are *Vanduzea arquata*, *Telamona ampelopsidis*, *Enchenopa binotata*, and *Ceresa bubalus*.

Station H, the inlet region from Renwick to State Street, Ithaca. The land consists of wet filled-in areas overgrown with vines and weeds. There is much sweet clover, ragweed, thistle, and goldenrod. The boathouses along the inlet and at the foot of Cascadilla Creek are covered with Virginia creeper. The waste lands yield various grass-inhabiting forms of Membracidae. This is one of the best stations in the basin for *Telamona ampelopsidis*, owing to the abundance of woodbine, on which this insect lives. *Campylenchia latipes* has been commonly taken near the Cornell boathouse by sweeping.

Station I, West Hill, extending to the top of the watershed. Farm lands, with much fruit, make up this section. Apple and pear trees in the region are infested with species of Stictocephala and Ceresa. Con-

siderable chestnut is found on the higher parts of the area. The chief species taken at this station are *Ceresa bubalus, Ceresa taurina, Stictocephala inermis, Atymna castaneae,* and *Telamona reclivata.*

Station J, Coy's Glen. This is a remarkable collecting ground with a great variety of species. On the northern slope of the gorge are several good stands of hawthorn and many butternuts. Considerable oak and maple is found thruout the glen and there are large numbers of shrubs and herbs. On the south slope are good stands of thistle, and at higher points there are a number of large oaks. Practically every species of membracids found in the basin has been taken in Coy's Glen, and it is probably the best station in the basin for *Glossonotus crataegi, Entylia bactriana,* and *Ceresa Palmeri.*

Station K, the west side of the valley from Coy's Glen to Newfield. Considerable fine old timber, particularly oak and chestnut, grows here. Farm lands and pastures make up the region. There are many neglected roadsides with good growths of elder, Virginia creeper, sweet clover, thistle, and ragweed. The rugged country gives a variety of floristic conditions. A number of species of the genus Telamona are found in this station, and *Ceresa diceros, Ceresa bubalus,* and *Campylenchia latipes* are abundant.

Station L, the floor of the valley between Ithaca and Enfield. This is rich swampy land, overgrown in places with daisy, thistle, sweet clover, and sedges. There is some butternut and oak. A few cultivated areas are found. *Ceresa bubalus, Enchenopa binotata, Campylenchia latipes, Stictocephala lutea,* and *Entylia bactriana* have been commonly taken at this station.

Station M, the hills on the east side of the valley from Buttermilk Falls southward. These slopes are densely wooded, mostly with second-growth timber — butternut, oak, hickory, maple, and pine. It is dark and gloomy under the trees and there is little underbrush. This is a poor station for Membracidae.

Station N, Buttermilk Gorge. The steep slopes of the gorge are thickly grown up with young oaks and maples. There are few herbaceous plants, but large areas of blackberries and raspberries are found. This is the best station in the basin for the genera Glossonotus and Telamona.

Station O, South Hill, from the Morse Chain Works to the village of Danby. This is a large territory, gradually ascending from Ithaca southward. There is little timber. One small clump of butternut in this

station has yielded the largest number of specimens of *Telamona unicolor* taken in the basin.

Station P, the territory along the Delaware, Lackawanna & Western Railroad from Ithaca to Brookton. This region consists of farm lands and occasional small patches of timber. The hillsides are often thickly covered with underbrush and sumac. There is considerable clover and timothy, and good stands of blackberry are found. This is a good collecting ground for most species of the genus Ceresa.

Station Q, the valley of Six Mile Creek. This is probably the best collecting ground in the basin. The floor of the valley is rich in sweet clover, elder, blackberry, aster, daisy, and joe-pye weed, all of which support Membracidae. In the lower parts of the valley are many locusts, elms, and young sycamores, on which certain species may be found the year round. The slopes are thickly wooded with a large variety of young trees, containing some stands of beech and dogwood, and considerable oak, butternut, and chestnut. *Telamona pruinosa* has been taken only at this station. *Vanduzea arquata* and *Thelia bimaculata* are extremely abundant. The entire life history of *Ceresa bubalus* has been worked out on the young elms and the sweet clover below the dam.

Station R, the region east of Ithaca between Six Mile Creek and the boundary of Station A. The section includes farm lands, a few timbered tracts, and the interesting Cascadilla Gorge. The last-named area is the richest part of the station and contains considerable Virginia creeper, elder, and small trees. The farms generally include fields of alfalfa and buckwheat. *Telamona ampelopsidis*, *Ceresa diceros*, and *Campylenchia latipes* are abundant in this region, and *Glossonotus crataegi* has occasionally been found.

Station S, Fall Creek valley from Forest Home eastward. This is a winding, sparsely wooded valley, rich in bushes and shrubs. The trees are generally small and scattered. The slopes of the valley are not precipitous and are often cultivated. Small crops, clover, alfalfa, potatoes, and timothy provide fair collecting opportunities.

Station T, the region northeast of Ithaca, from the golf links over a rambling territory. There are scattered patches of timber, well-wooded roadsides, some fruit trees, and a great deal of goldenrod, thistle, joe-pye weed, aster, and sweet clover. The sweeping is excellent in this region.

Station U, the territory on the east side of the lake north of Aurora. This station has been the least worked of all of the regions represented, only two or three collecting trips having been made in this part of the basin. The country is sparsely wooded and well cultivated. There is considerable fruit and much grain. Few records have been obtained from this station.

Station V, the Montezuma Marshes and neighboring territory. A considerable number of records from this station have accumulated as a result of collecting done by members of parties visiting the marshes on botanical excursions. The region is rich in swamp flora and the Membracidae taken have been largely grass- and shrub-inhabiting forms. This is one of the few regions where *Publilia concava* has been found.

COLLECTIONS

The collections used as a basis for determinations and comparisons in the course of this study have been largely the Cornell University collection, the New York State Museum collection at Albany, the collection in the United States National Museum at Washington, D. C., the collection in the Philadelphia Academy of Science, the private collection of E. P. Van Duzee, of the University of California, and the private collection of the author.

The Cornell University collection of Membracidae is very complete in local forms of the family, having been built up by the addition of departmental material, students' collections, and purchased material, thru a period of many years. It includes paratypes of the species described by Van Duzee (1908 a) and a large proportion of the material has been determined by this authority. Representatives of nearly all of the species here mentioned are to be found in this collection.

The New York State Museum collection, at Albany, New York, is extremely valuable owing to the fact that it contains the types of Fitch's species, described by him many years ago (Fitch, 1851). Thru the courtesy of Dr. E. P. Felt it has been possible to compare the material from the basin with this type material, and the author is greatly indebted to Dr. Felt and to Mr. Young for their continued kindness and interest in this respect. Fitch's types are kept separate from the remainder of the collection, and have proved extremely valuable for comparison since they include a number of the forms here discussed (Funkhouser, 1915 d).

The collection in the United States National Museum, while in some confusion as to arrangement and difficult of access for systematic purposes, is rich in New York State material and contains valuable representatives of the forms found locally. Dr. Crawford and the late Mr. O. Heidemann have kindly permitted the author to study this collection and compare local specimens with the museum forms.

In like manner the collection of the Philadelphia Academy of Science has been studied with special reference to New York material. This collection, while not extensive, has yielded some valuable data.

While residing in Buffalo, New York, Mr. Van Duzee extended to the author the privilege of inspecting his very complete private collection, which contains a number of types of the species in question. The enjoyable visit to Mr. Van Duzee's home at that time and the valuable suggestions offered then and in later correspondence have been most appreciated.

The author's collection has been built up during the past eight years and contains all but two of the species here mentioned. The collection is strong in having long series of most of the species, the result of extensive collecting in the basin during this period. In most cases the specimens have been compared with types or paratypes and are so labeled.

The authorities used have been largely the above-mentioned collections, and reports by the authors noted. Mr. Van Duzee's work (1908a) on the North American forms is the most valuable systematic paper relating to the subject; while the report of Hodgkiss (1910) is reliable for the life-history records of the four species which he discusses. Original descriptions have been consulted in all cases and an attempt has been made to verify the synonymy to date.

The validity of most of the species has been apparently established. In the few doubtful cases the subject is discussed in connection with the species in question. The study of a long series of specimens of one species, showing much variation and gradation, naturally brings up the question of overlapping, convergence, or hybridizing; but the species are here considered as good unless sufficient data are available to leave no doubt in the matter. It may develop that in the genera Telamona and Cyrtolobus certain species here recognized will fall, but considerably more biologic proof will be needed before such cases can be established.

COMPARISON OF CAYUGA LAKE BASIN WITH THE STATE AS A WHOLE

It is interesting to note that of the seventy-six species of Membracidae recorded for New York State, sixty-one have been found in the Cayuga Lake Basin. It can hardly be argued that this is due to more rigorous collecting in this region, for New York State has been for many years a center for entomological investigation. Fitch and Emmons, at Albany, were much interested in Hemiptera, and doubtless surveyed the region about the capital very thoroly; more recently Lintner and Felt have had opportunity to study material not only from the Hudson River Valley but from practically every part of the State; the entomologists in and about New York City and Brooklyn have always been active, and it is reasonable to suppose that few new species will be recorded from that region; Mr. Van Duzee, residing for many years in Buffalo, has covered as an ardent systematic hemipterist the territory about that city; and the various experiment stations and granges thruout the State have kept careful watch of insect material. It is only fair to presume that the state records are reasonably complete and that the Cayuga Lake Basin is unusually well supplied with species of the family under discussion.

The large proportion of species represented is more surprising when it is remembered that many of the State forms are recorded only from Long Island and Staten Island, and that these regions represent a faunal area quite distinct from the remainder of the State.

THEORIES OF ORIGIN AND PATHS OF MIGRATION

The Membracidae are primarily a tropical and subtropical family. Of over three hundred genera established in the family, only forty are found in North America; and of these a number are represented by a single species only. The great home of the membracids is apparently South America, with Africa and southern Asia offering hardly less abundant forms. The hypotheses of origin and distribution of the family are largely conjectural, as there is no paleontological evidence to be used as a basis and the theories can be formulated only with reference to other more fully established theories as worked out for other forms of plant and animal life. No fossil membracids have been discovered, altho, singularly enough, the closely related families of Cercopidae, Fulgoridae, and Aphididae are represented in paleontological literature.

Buckton (1903:204) has suggested that previous to the glacial period, when " the monkey and the palm-tree occurred within the limits of the Arctic Circle," the Membracidae may have become distributed by a northern route. This theory can be attacked, of course, from a number of angles, but such criticism is here unnecessary.

The older authors were unanimous in treating the Membracidae from a strictly geographical viewpoint. Thus, Stål considered separately the membracids of Africa, Mexico, South America, and the Philippine Islands, and established for each geographical area new genera and species, with separate keys and tables for each. The result of such work has been a useless accumulation of synonyms and an incorrect idea of the definiteness of geographical barriers.

It is now known that the same genera, and in a few cases the same species, of Membracidae may occur in widely separated continents. The forms of Asia merge gradually into those of the Philippines, and these in turn into those of the East Indies and Australia. The South American forms are closely related to those of Africa, while the Palearctic and Nearctic forms are entirely distinct.

It seems more reasonable, therefore, to presume that the Membracidae originated as tropical forms; that the first migration was eastward and westward in equatorial regions; and that later the forms migrated northward and southward on the respective land-masses of the eastern and the western hemisphere, their limits of distribution depending on the adaptability of the species to environmental, and particularly to climatic and floristic, conditions. Records of distribution from all parts of the world bear out such an hypothesis to a large extent, and the geological theories of land bridges and life zones in comparatively recent times, as used to explain the appearance particularly of birds and mammals, are sufficient to account for earlier tropical migrations.

As considered in regard to the modern geographical areas as life zones, the Membracidae are represented as follows:

Palearctic region

(Europe, the temperate parts of Asia, and the north of Africa; Iceland and the islands of the Atlantic; limited by the Himalayas)

Very poorly represented. Only two or three genera on the entire continent of Europe, but two species in Great Britain, two species in Russia, and none reported from Iceland. A few in northern Africa, chiefly forms that have migrated from the South.

Ethiopian region

(Africa and its islands except the northern parts; Arabia)

Rich in genera and species. Little work has been done on these forms of the family, but there is evidence of an abundant membracid fauna.

Oriental region

(India and the East Indies)

Extremely rich both in number of forms represented and in number of individuals. The center of distribution for the subfamily Centrotinae.

Australian region

(Australia, New Zealand, and neighboring islands)

Well represented by rather distinct forms. The region has been fairly well worked and has yielded a large number of species.

Nearctic region

(America north of Mexico; Greenland)

Forty or fifty genera, gradually becoming less abundant northward. A few species common in Canada as far north as Perry Sound. None reported from Greenland.

Neotropical region

(Mexico, West Indies, Central and South America)

The most important of all the regions for the Membracidae. Central America and the northern part of South America have yielded as many species as all the rest of the world together.

In North America the family is best represented in Mexico, where the characteristic bizarre forms are plentiful. Southern United States shows fewer species and these lose their grotesque appearance as they spread northward. Northern United States continues to show the thinning-out of the forms as the climate becomes colder, and the native species are on the whole smaller and of less striking development. Canada, as has been noted, marks the northern limit of the family and shows few representatives.

New York State, either because it includes a transitional zone or because the fauna has been more intensively studied, yields more Membracidae than any other northern State. The species, however, are not characteristic of the family and show little of the striking appearances of the exotic forms.

As has been remarked, the Cayuga Lake Basin is surprisingly well represented in the forms common to the State. It is to be noted, however, that both in the State and in the basin two of the great tropical subfamilies — Darninae and Hoplophorinae — are entirely without representatives.

In connection with the discussion of faunal and floral areas it may be noted that Bray (1915:70–79) recognizes six plant zones in New York State, as follows:

A. Zone of willow oak, sweet gum, persimmon, etc.
   Staten Island, southern Long Island, and narrow belt along northern shore of Long Island Sound.

B. Zone of oaks, hickories, chestnut, etc.
   Morainic region of Long Island and Staten Island; Hudson Valley; Delaware, Susquehanna, and Alleghany drainage valleys, etc.

C. Alleghany-Transition Forest Zone of sugar maple, beech, yellow birch, etc.
   Alleghany plateau region and Catskills below the spruce-balsam zone. Favorable edaphic situations thruout the State up to about 2000 feet.

D. Canadian-Transition Zone of Zone C species, with a tendency toward dominance of red spruce, balsam, and mountain ash.
   Catskills from 2000 to 3700 feet, and Adirondacks up to 3500 feet.

E. Canadian Zone of red spruce, balsam, and paper birch.
   Highest Catskills, and Adirondacks above 3500 feet.

F. Arctic flora of Adirondack peaks. Zone of fir club-moss, alpine holy-grass, mountain spear-grass, etc.
   Summit of Mount Marcy above 5000 feet; Mount McIntyre and Whiteface summits.

KEYS TO GENERA AND SPECIES OF THE CAYUGA LAKE BASIN, WITH TECHNICAL DESCRIPTIONS AND LIFE HISTORIES

The following review attempts to establish the taxonomic position of each genus and species, and includes for each form a short bibliography, a technical description, and the more important facts regarding life history, local distribution, and relative abundance.

In the systematic discussion the genera and the species are located by means of keys and descriptions so that they may be easily distinguished. The dichotomous tables used are admittedly artificial in many respects, but it is believed that with the limited number of forms involved they will prove satisfactory. In all cases, of course, the function of such keys is to direct rather than to establish, and the description, rather than the key, should be considered for final verification.

In the course of several years of rather diligent collecting, there has naturally accumulated a certain amount of material which cannot be assigned to any of the described species. Some of these specimens are probably color or sexual varieties of forms here discussed; some may be sports, or mutants; a few will likely prove to be new species; but all are ignored in this study. It is believed that no new species should be described in this family unless a good series of both sexes is available,

and this is not the case with the material at hand. It is also apparent that if new species are established the descriptions should not appear in a report of this type; the undetermined material is therefore not discussed further in this paper. It is safe to assume, however, that the sixty-one species here recognized do not represent all the forms of the basin and that future collecting will result in additions to the list.

Because of the fact that the literature relating to the family Membracidae is widely scattered and in many cases not readily accessible, it has been deemed advisable to include for each of the local species a short bibliography containing references of the greatest importance and including the reference to the original description. It happens, however, that many of the original descriptions are very meager and the species have never been redescribed. For this reason it is often difficult for the student to recognize the species unless carefully determined material is available for comparison. For each species, therefore, there is given a short technical description, which, it is believed, will enable the student to recognize at once the species under discussion without referring to other papers or to collections. These descriptions have been written in each case from type or paratype specimens, from specimens compared with types, or from material determined for the Cornell collection or for the author's collection by recognized authorities. With such data at hand it should be possible to recognize even the rarer forms, should such forms be again encountered in the basin. All terms used in the technical descriptions are fully explained in the section of this paper dealing with the external anatomy.

It should be noted that the measurements given in the technical descriptions of all the species are maximum lengths and widths unless otherwise noted. The length is considered as the greatest distance from the front of the head to the tips of the tegmina; the width as the greatest width of body, which is usually found at the humeral angles or from tip to tip of the suprahumeral horns when such structures are present. The structures are generally described as seen from a lateral view, since such an aspect of the insect usually shows most of the characters needed for systematic diagnosis. The term *tegmina* has been used thruout to refer to the front wings, since this word seems to have been generally adopted in the best terminology of the group and is a convenient term to prevent confusion in wing discussion.

The three subfamilies represented may be distinguished as follows:

Scutellum distinct	Centrotinae
Scutellum wanting or concealed by the pronotum.	
Anterior tibiae foliaceous	Membracinae
Anterior tibiae simple	Smiliinae

SUBFAMILY CENTROTINAE

Very few species of the subfamily Centrotinae are found outside of the tropical regions, and of these but one occurs in the Cayuga Lake Basin. The subfamily may be at once distinguished by the fact that the scutellum is present and is usually visible below or behind the pronotum.

The genus Microcentrus Stål

The one species found locally, *Microcentrus caryae* Fitch, is not a typical representative of the subfamily in that it does not show the grotesque development of the pronotum which is characteristic of most of the species of this division of the Membracidae.

1. *Microcentrus caryae* Fitch (Plate XXIII, 1, 2)

1851 *Uroxiphus caryae* Fitch, Cat. Ins. N. Y., p. 52.
1851 *Centrotus caryae* Walk., List Hom. B. M., p 1147.
1856 *Uroxiphus caryae* Fitch, Rept. Ins. N. Y. 3:450.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:450.
1858 Walk., List Hom. B. M. Suppl., p. 341.
1869 Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1869 *Microcentrus caryae* Stål, Bid. Memb. Kän., p. 295.
1890 Smith, Ins. N. J., p. 440.
1890 Van Duzee, Psyche 5:391.
1890 *Uroxiphus caryae* Packard, Ins. Inj. For. and Shade Trees, p. 324.
1891 *Microcentrus caryae* Osborn, Iowa Acad. Sci. 1²:128.
1892 Godg., Ins. Life 5:92.
1893 Godg., Can. Ent. 25:172.
1894 Godg., Cat. Memb. N. A., p. 474.
1896 *Uroxiphus caryae* Fowler, B. C. A., p. 159.
1896 *Phaulocentrus caryae* Fowler, B. C. A., p. 159.
1903 *Microcentrus caryae* Buckt., Mon. Memb., p. 268.
1908 Van Duzee, Stud. N. A. Memb., p. 117.
1909 Smith, Ins. N. J., p. 94.
1910 Matausch, Journ. N. Y. Ent. Soc. 18:170.
1915 Funkh., Fitch's Types, p. 50.
1915 Metcalf, Hom. No. Car., p. 10.

Fairly common thruout the basin on hickory. Usually on young trees and preferring the higher branches. Since it is the only local representative of the subfamily Centrotinae, it may be easily distinguished from

PLATE XXIII

1, Lateral outline of prothorax and tegmen of *Microcentrus caryae* Fitch, showing scutellum; 2, front view

3, Lateral outline of *Campylenchia latipes* Say, adult; 4, head; 5, lateral outline of last nymphal instar

6, Egg masses of *Enchenopa binotata* Say; 7, single egg; 8, frothy egg-covering; 9, egg slits in wood; 10–14, nymphal instars; 15, head of adult; 16, adult

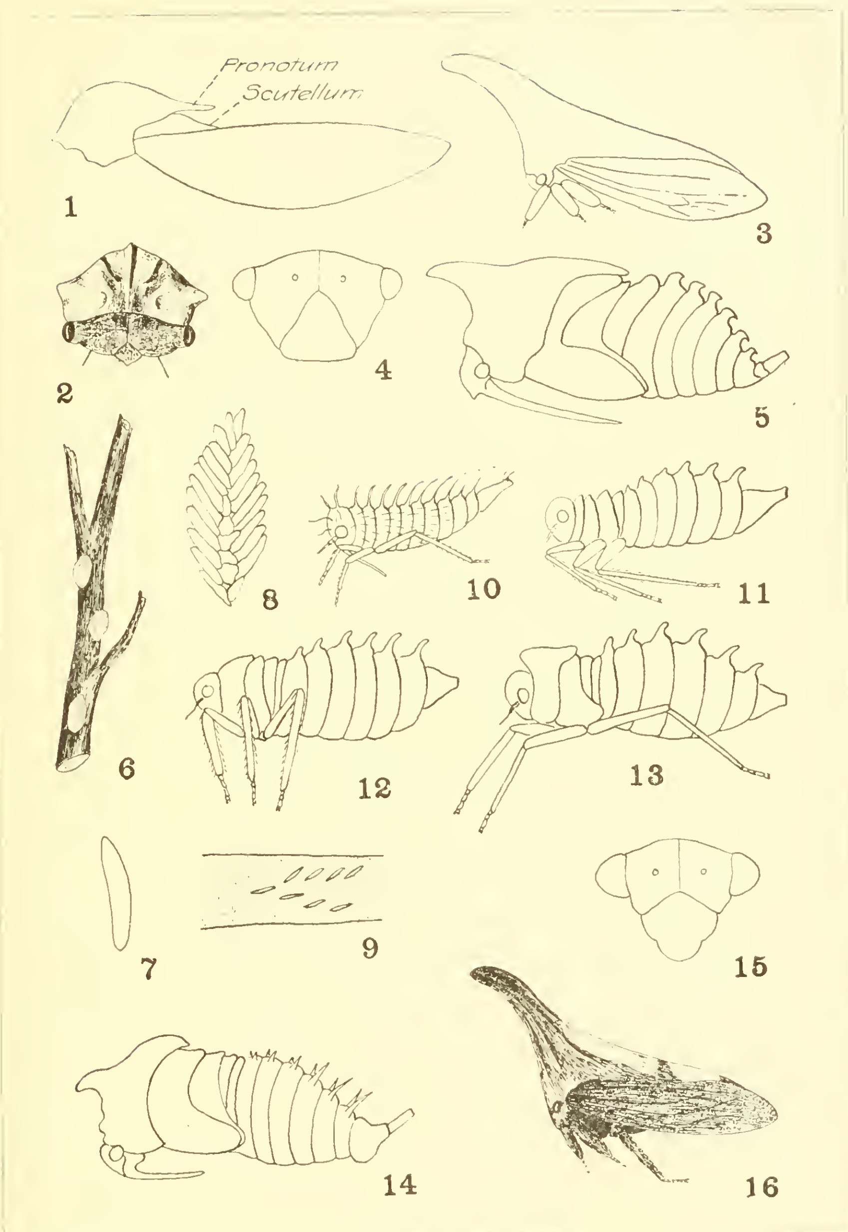


Plate XXIII

all other species of Membracidae by the uncovered scutellum. In general appearance this insect suggests a large cercopid.

The life history of this species has not been completely worked out owing to the fact that no way has been found of rearing the nymphs in the laboratory. The first nymphs have been observed on August 13. The eggs are laid in young stems, and there is reason to believe that they may also be laid in the buds altho such oviposition has not actually been observed. The eggs winter over and are slow to hatch, making the species rather late in appearing. There is apparently but one brood a year. It is most numerous in Stations J, K, and N.

Technical description.— Gray-brown mottled with black; entire body broad and flat; pronotum roundly swollen above line of abdomen and wings; wings broadly tectiform.

Head perpendicular, twice as broad as long, roughly sculptured, closely punctate, densely pubescent, deep brown at base; eyes prominent, extending beyond lateral margins of pronotum, dark brown margined with lighter; ocelli small, pearly, farther from the eyes than from each other, with deep depression between them; clypeus prominent, broad, lighter in color than vertex above, extending far below lateral margin of head.

Prothorax subspherical with high median carina, coarsely punctate, pubescent; light brown marked with black on median ridge and above head; posterior margin truncate except for narrow process which projects to angles of tegmina and short sharp tooth on each latero-posterior angle. Scutellum broadly exposed, wide at base, truncate at tip, which does not reach apex of posterior process.

Tegmina translucent, pubescent, inner margins straight and meeting at median dorsal line; veins prominent and nodulate; apices of tegmina extending beyond tip of abdomen. Legs and undersurface of body light brown mottled with white. Undersurface of abdomen often tomentose.

Length 9–10 mm.; width 3 mm.

SUBFAMILY MEMBRACINAE

The basin yields two species of the subfamily Membracinae, belonging to two different genera — Campylenchia and Enchenopa. These genera may be distinguished from each other by the characters of the pronotal horn. In Campylenchia the lateral ridges of the anterior horn are located close to the superior margin, and the inferior carina is not foliaceous; in Enchenopa the lateral ridges are located about equally distant from the superior and inferior margins, and both the superior and the inferior carina are foliaceous.

The genus Campylenchia Stål

2. *Campylenchia latipes* Say (Plate XXIII, 3–5)

1824	*Membracis latipes*	Say, Narr. Long's Exp. App., p. 302.
1842		Harris, Treatise, p. 178.
1846		Fairm., Rev. Memb., p. 252, no. 32.

1851 *Enchenopa latipes* Walk., List Hom. B. M., p. 482.
1851 *Enchophyllum latipes* Fitch, Cat. Ins. N. Y., p. 47.
1851 *Enchenopa antonia* Walk., List Hom. B. M., p. 488.
1851 *Enchenopa venosa* Walk., List Hom. B. M., p. 488.
1851 *Enchenopa frigida* Walk., List Hom. B. M., p. 490.
1851 *Enchenopa bimacula* Walk., List Hom. B. M., p. 491.
1858 *Enchenopa frigida* Walk., List Hom. B. M. Suppl., p. 126.
1859 *Membracis latipes* Say, Compl. Writ. 1:202.
1862 *Enchenopa latipes* Uhler, Harris' Treatise, p. 221.
1869 *Campylenchia curvata* Stål (part), Hem. Fab. 2:43.
1876 *Enchenopa curvata* Uhler, List Hem. West Miss. River, p. 343.
1877 Uhler, Rept. Hem. Colo., 1875, p. 457.
1877 *Campylenchia curvata* Uhler, Wheeler's Rept. App. J, no. 1333.
1877 *Aconophora curvata* Butler, Cist. Ent. 2:349, no. 16.
1886 *Enchenopa latipes* Prov., Petite Faune Can. 3:229.
1888 *Enchenopa curvata* Comstock, Int. Ent., p. 172.
1890 *Campylenchia curvata* Smith, Ins. N. J., p. 440.
1891 *Enchenopa curvata* Osborn, Iowa Acad. Sci. 1^2:128.
1892 *Campylenchia curvata* Godg., Ins. Life 5:93.
1893 Gossard, Iowa Acad. Sci. 1^3:97.
1894 Godg., Cat. Memb. N. A., p. 464.
1895 Gillette and Baker, Hem. Colo., p. 68.
1903 *Enchenopa rectidorsum* Buckt., Mon. Memb., p. 49.
1903 *Enchenopa antonia* Buckt., Mon. Memb., p. 51.
1903 *Enchenopa curvata* Buckt., Mon. Memb., p. 52.
1903 *Enchenopa venosa* Buckt., Mon. Memb., p. 52.
1903 *Enchenopa frigida* Buckt., Mon. Memb., p. 52.
1903 *Aconophora curvata* Buckt., Mon. Memb., p. 133.
1905 *Campylenchia curvata* Van Duzee, N. Y. St. Mus. Bul. 97:552.
1908 Van Duzee, Can. Ent. 40:115.
1908 Van Duzee, Stud. N. A. Memb., p. 111.
1909 Smith, Ins. N. J., p. 93.
1910 Matausch, Journ. N. Y. Ent. Soc. 18:170.
1912 Matausch, Psyche 19:69.
1912 Matausch, Bul. Amer. Mus. Nat. Hist. 31:336, pl. 32, fig. 17.
1913 Branch, Kans. Univ. Sci. Bul. 8:77, 111, figs. 11, 70, 86.
1913 Funkh., Hom. Wing Veins, figs. 52, 72.
1914 Kornh., Arch. Zellf. 12.
1914 Van Duzee, Can. Ent. 46:389.
1914 Bromley, Psyche 21:195.
1914 *Campylenchia latipes* Van Duzee, Can. Ent. 46:389.
1915 Metcalf, Hom. No. Car., p. 9.
1915 *Campylenchia curvata* Ball, Ann. Ent. Soc. Amer. 8:368.
1916 Van Duzee, Check List Hem., p. 62.
1916 *Campylenchia latipes* Van Duzee, Check List Hem., p. 62, no. 1734.

Abundant in all parts of the basin. A grass-inhabiting species. Common in pastures and especially on alfalfa. Varies much in color and in the length of the pronotal horn. May be at once distinguished from *Enchenopa binotata* Say, the only other local representative of the subfamily Membracinae, by the lack of yellow markings on the dorsum. Usually taken in sweeping.

The imagoes have been reared from nymphs of the third instar found on alfalfa the first week in June, but these imagoes refused to oviposit in the laboratory. In the field the eggs are laid in the base of the stem and in the upper parts of the roots of alfalfa, sweet clover, or goldenrod. These eggs winter over in the above-named parts of the plants, which persist from one season to another. Specimens of this species collected at Saranac Lake, New York, on August 26, 1916, were found abundantly on both goldenrod and thistle, in the stems of which plants the eggs were found at that date, together with many evidences of former egg masses and of egg slits of the past season. At Saranac Lake, also, the species was attended by ants, which is not true of the local forms.

Apparently some adults winter over, for mature specimens have been collected as early as May 1, long before it would be possible for eggs to hatch and nymphs to mature. The nymphs of the first three instars are rarely seen and it is not known where they secrete themselves; but nymphs of the last two instars begin to appear commonly about the middle of June, and by the first of July the adults are numerous.

Technical description.— Uniform cinnamon brown, densely punctate, sparingly pubescent; single porrect pronotal horn projecting forward over head; head and first two pairs of legs broadly foliaceous, hind legs spined; tegmina opaque, punctate at basal and costal margins.

Head quadrate, somewhat declined, shining brown somewhat mottled with darker, lightly punctate, densely pubescent; eyes prominent; ocelli small, pearly, equidistant from each other and from the eyes and situated on a line passing thru centers of eyes; clypeus very broad, shining, scarcely punctate, broadly truncate at apex, tip strongly pubescent.

Prothorax produced anteriorly into a long, flattened horn, ridged in center and foliaceous above and below, varying greatly in length and degree of curve; posterior process strong, tectiform, reaching internal angles of tegmina; median dorsal carina strong and percurrent; entire pronotum concolorous, lightly punctate, sparingly pubescent with golden hairs; median lateral ridge reaching lateral margin.

Tegmina yellow-opaque; basal and costal areas punctate and pubescent; veins distinct, broad, and slightly pubescent; five apical and two discoidal cells; hind wings iridescent. Two anterior pairs of legs broadly spatulate and lightly pubescent at margins; posterior tibiae armed with black-tipped spines; tarsi much produced and lighter in color. Undersurface of body chocolate brown.

Length: from head to apices of elytra, 5 mm.; from tip of pronotal horn to apices of elytra, 8 mm. Width between humeral angles, 2 mm.

The genus Enchenopa A. & S.

3. *Enchenopa binotata* Say (Plate XXIII, 6–16)

1824	*Membracis binotata*	Say, Narr. Long's Exp. App., p. 301.
1835		Germ., Silb. Rev. 3:226.
1840		Blanch., Hist. Nat. Ins. 3:179.
1841		Harris, Rept. Ins. Mass., p. 181.
1842		Harris, Treatise, p. 178.
1842		Harris, Treatise, p. 181.
1846		Fairm., Rev. Memb., p. 251, no. 29.

1851 *Enchophyllum binotatum* Fitch, Cat. Ins. N. Y., p. 47.
1851 *Enchenopa binotata* Walk., List Hom. B. M., p. 481.
1851 *Enchenopa brevis* Walk., List Hom. B. M., p. 492.
1854 *Enchophyllum binotatum* Emm., N. Y. Agr. Rept. 5:pl. 13, fig. 17.
1854 *Thelia binotata* Emm., N. Y. Agr. Rept. 5:156.
1856 *Enchenopa binotata* Fitch, Rept. Ins. N. Y. 3:146.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:464.
1858 *Enchenopa bifusifera* Walk., List Hom. B. M. Suppl., p. 125.
1859 *Membracis binotata* Say, Compl. Writ. 2:201.
1862 Harris, Treatise, p. 221, 224.
1862 Uhler, Harris' Treatise, p. 221.
1869 *Enchophyllum binotatum* Walsh and Riley, Amer. Ent. 1:248.
1869 *Enchenopa binotata* Stål, Bid. Memb. Kän., p. 272.
1869 *Enchenopa bifusifera* Stål, Bid. Memb. Kän., p. 273.
1877 *Enchenopa binotata* Glover, Rept. U. S. Dept. Agr., p. 28, fig. 11.
1878 Glover, MS. Journ. Hom., pl. 1, fig. 22.
1880 Riley, Amer. Ent. 3:254.
1880 *Enchophyllum binotatum* Lintner, Count. Gent. 45:711.
1881 Riley, Amer. Nat. 15:574.
1882 *Enchenopa binotata* Lintner, First Rept. Ins. N. Y., p. 281.
1883 Saunders, Ins. Inj. Fruits, p. 242.
1885 Dimmock, Psyche 4:241.
1886 Prov., Petite Faune Can. 3:229.
1887 Lintner, Count. Gent. 52:783.
1888 Comstock, Int. Ent., p. 172, fig. 142.
1889 Van Duzee, Can. Ent. 21:6.
1890 Van Duzee, Psyche 5:389.
1890 Packard, Ins. Inj. For. and Shade Trees, p. 341, 512.
1890 Smith, Ins. N. J., p. 440.
1891 Osborn, Iowa Acad. Sci. 1[2]:128.
1892 Godg., Ins. Life 5:93.
1893 Hopkins, W. Va. Agr. Exp. Sta. Bul. 32:230.
1894 *Enchenopa brevis* Godg., Cat. Memb. N. A., p. 463.
1894 *Enchenopa bifusifera* Godg., Cat. Memb. N. A., p. 463.
1894 *Enchenopa binotata* Fowler, B. C. A., p. 9.
1894 Bruner, Rept. Nebr. Hort. Soc. 25:162.
1900 Lugger, Minn. Agr. Exp. Sta. Bul. 69:113–114.
1901 Howard, Ins. Book, p. 268, fig. 132.
1903 Buckt., Mon. Memb., p. 46, pl. 5, fig. 3, 3a.
1903 *Enchenopa porrecta* Buckt., Mon. Memb., p. 51, pl. 6, fig. 5–5b.
1905 *Enchenopa binotata* Kellogg, Amer. Ins., p. 168.
1908 Van Duzee, Can. Ent. 40:115.
1908 Van Duzee, Stud. N. A. Memb., p. 112
1909 Smith, Ins. N. J., p. 93.
1910 Comstock, Man. Stud. Ins., p. 155, fig. 193.
1912 Sand. and Jack., Elem. Ent., p. 124, fig. 169.
1912 Matausch, Journ. N. Y. Ent. Soc. 20:58, pls. 5, 6.
1912 Matausch, Bul. Amer. Mus. Nat. Hist. 31:336.
1913 Funkh., Hom. Wing Veins, fig. 53.
1913 Branch, Kans. Univ. Sci. Bul. 8:79.
1913 *Enchenopa porrecta* Branch, Kans. Univ. Sci. Bul. 8:111.
1913 *Enchenopa permutata* Branch, Kans. Univ. Sci. Bul. 8:111.
1914 *Enchenopa binotata* Kornh., Arch. Zellf. 12.
1915 Funkh., Journ. Econ. Ent. 8:368–371.
1915 Metcalf, Hom. No. Car., p. 10.
1916 Van Duzee, Check List Hem., p. 62, no. 1735.

A very abundant species on trees, shrubs, and vines. Particularly common on butternut, locust, and bittersweet. Seldom found in the grass, in which respect it differs from the preceding species. The forms on the butternut are peculiar in egg-laying habits and in coloration. This species is unique in covering its egg masses with a frothy deposit. It is destructive to certain hosts because of the puncturing of buds and stems in egg-laying.

This insect shows two very distinct types of life history in the Cayuga Lake Basin. In the usual method the eggs are laid in the stems of the locust or the bittersweet and covered with the characteristic frothy mass (Plate XXIII, 6, 8), which has often been confused in literature with other insect deposits. The eggs winter over, the nymphs appearing early in May and requiring about six weeks for development. The adults usually spend their lives on the host on which the eggs are laid, but occasionally they migrate to succulent plants, such as daisy, joe-pye weed, and the like, to feed. They return to the original host during the latter part of August to oviposit. The mature insects are light brown in color, with the males slightly darker than the females. This is apparently the normal life history of the species and has been very completely described by Matausch (1912 a).

The second type of life history is found on the butternut, on which host the eggs are laid in the buds and are not covered with the heavy froth, and the adults are very different in color. This peculiar life history has been described by the author in an earlier paper (Funkhouser, 1915 c).

There is only one brood a year, but the nymphs are variable in the length of time taken for development and may be found in various stages thruout the greater part of the summer. The species is most abundant in Stations A, B, and L. It should be noted that this species is not attended by ants.

Technical description.— Much resembling the preceding species in size and in general appearance, but differing in shape of the head, in shape of sculpturing of the pronotal horn, and in bearing two yellow spots on the dorsal line of the pronotum.

Head longer than broad, uniform brown, finely but densely punctate, sparingly pubescent; eyes prominent, very deep brown; ocelli yellowish, farther from each other than from the eyes; clypeus longer than broad, rounded at tip, not punctate.

Prothorax finely punctate, sparsely pubescent; two distinct ridges on each side, the upper extending to the lateral margin; pronotal horn strongly curved, broadly foliaceous above, triquerate at tip; median dorsal carina high and percurrent; two dorsal spots of lemon yellow, the anterior about twice as long as the posterior; posterior process gradually acuminate, extending slightly beyond internal angles of tegmina.

Tegmina concolorous brown, opaque, costal margins slightly punctate, and feebly pubescent at base; veins distinct; five apical and one discoidal cell. First two pairs of legs broadly foliaceous; hind tibiae spined; tarsi thin.
Length 5 mm.; width 2 mm.

SUBFAMILY SMILIINAE

By far the largest number of the species of Membracidae in the United States belong to the subfamily Smiliinae, and it is as representatives of this subfamily that all the remaining species of the Cayuga Lake Basin are to be considered.

The division is a large one and includes many genera. These genera may be separated by the following key:

A. Elytra entirely free; not covered by pronotum.
  a. Veins of corium closely united at base.
    b. Suprahumeral horns present . . . . . Ceresa
    bb. Suprahumeral horns absent . . . . . Stictocephala
  aa. Veins of corium widely separated at base.
    b. Elytra with five apical areas; veins distinct . . . . . Acutalis
    bb. Elytra with four apical areas; veins indistinct . . . . . Micrutalis
AA. Elytra partly or entirely covered by pronotum.
  a. Terminal cell of hind wing sessile, its base truncate.
    b. Pronotum without horn or crest.
      c. Dorsum low and rounded . . . . . Carynota
      cc. Dorsum high, compressed, and foliaceous . . . . . Archasia
    bb. Pronotum with horn or crest.
      c. Horn anterior and porrect . . . . . Thelia
      cc. Horn a flat dorsal crest.
        d. Crest arising from between humeral angles . . . . . Glossonotus
        dd. Crest arising from behind humeral angles.
          e. Crest step-shaped . . . . . Heliria
          ee. Crest not step-shaped . . . . . Telamona
  aa. Terminal cell of hind wing triangular and petiolate.
    b. Base of corium with three veins.
      c. Corium without cross-vein at base . . . . . Smilia
      cc. Corium with cross-vein at base.
        d. Dorsum rounded . . . . . Ophiderma
        dd. Dorsum strongly compressed.
          e. Pronotum inflated posteriorly . . . . . Xantholobus
          ee. Pronotum not inflated posteriorly.
            f. Crest highest anteriorly . . . . . Atymna
            ff. Crest highest near middle . . . . . Cyrtolobus
    bb. Base of corium with two veins.
      c. Apical cell of tegmen transverse . . . . . Vanduzea
      cc. Apical cell of tegmen triangular.
        d. Dorsum strongly elevated, with deep median notch . . . . . Entylia
        dd. Dorsum only slightly elevated, with weak median depression . Publilia

The genus Ceresa A. & S.

The first of the genera of the Smiliinae to be considered is the genus Ceresa, of which seven species are represented in the basin. This genus

is usually recognized by its green color and its prominent suprahumeral horns. It is one of the most widely distributed of the genera of this subfamily. The species may be separated by the following key:

a. Brown with transverse bands .... *diceros*
aa. Green or greenish without bands.
  b. Undersurface of body strongly marked with black .... *basalis*
  bb. Undersurface of body not strongly marked with black.
    c. Dorsal crest marked with brown or reddish; species small.
      d. Horns long, sharp, much recurved and elevated .... *constans*
      dd. Horns short, little elevated, only slightly recurved .... *Palmeri*
    cc. Dorsal crest concolorous.
      d. Small, 7–8 mm.; very hairy .... *borealis*
      dd. Large, 8–10 mm.; hairs if present scattered.
        e. Horns long, sloping upward and recurved; clypeus much prolonged beyond vertex .... *taurina*
        ee. Horns stout, nearly straight; clypeus short .... *bubalus*

4. *Ceresa diceros* Say (Plate XXIV, 1, 2)

1824 *Membracis diceros* Say, Narr. Long's Exp. App., p. 299.
1835 *Smilia diceros* Germ., Silb. Rev. 3:237.
1840 *Membracis diceros* Blanch., Hist. Nat. Ins. 3:181.
1842 Harris, Treatise, p. 178.
1843 *Ceresa postfasciata* A. & S., Hem., p. 540, pl. 10, fig. 3.
1846 *Ceresa diceros* Fairm., Rev. Memb., p. 285, no. 11.
1851 Fitch, Cat. Ins. N. Y., p. 50.
1851 Walk., List Hom. B. M., p. 527.
1854 Emm., N. Y. Agr. Rept. 5:pl. 3, fig. 16.
1859 *Membracis diceros* Say, Compl. Writ. 1:199.
1862 Harris, Treatise, p. 221.
1862 *Ceresa diceros* Uhler, Harris' Treatise, p. 221.
1869 Stål, Bid. Memb. Kän., p. 245.
1869 Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1872 Uhler, List Hem. Colo. and N. Mex., p. 472.
1876 Uhler, List Hem. West Miss. River, p. 343.
1877 Glover, Rept. U. S. Dept. Agr., p. 29, fig. 16.
1877 Butler, Cist. Ent. 2:215, no. 1.
1878 Uhler, List Hem. Dak. and Mont., p. 509.
1878 Glover, MS. Journ. Hem., pl. I, figs. 27, 28.
1886 Prov., Petite Faune Can. 3:234.
1888 Comstock, Int. Ent., p. 172.
1889 Van Duzee, Can. Ent. 21:6.
1890 Van Duzee, Psyche 5:389.
1890 Smith, Ins. N. J., p. 441.
1891 Osborn, Iowa Acad. Sci. 1²:128.
1892 Godg., Ins. Life 5:92.
1894 Godg., Cat. Memb. N. A., p. 400.
1895 Gillette and Baker, Hem. Colo., p. 66.
1900 Lugger, Minn. Agr. Exp. Sta. Bul. 69:110.
1903 Buckt., Mon. Memb., p. 169, pl. 35, figs. 2–3a.
1903 *Ceresa vitidalis* Buckt., Mon. Memb., p. 172, pl. 36, figs. 3–3b.
1905 *Ceresa diceros* Van Duzee, N. Y. St. Mus. Bul. 97:552.
1908 Van Duzee, Stud. N. A. Memb., p. 35, pl. 1, fig. 12.
1909 Smith, Ins. N. J., p. 90.

1910 *Ceresa diceros* Matausch, Journ. N. Y. Ent. Soc. 18:164.
1913 Funkh., Hom. Wing Veins, figs. 13, 14, 29.
1913 Branch, Kans. Univ. Sci. Bul. 8:80, 100.
1914 Bromley, Psyche 21:195.
1915 Metcalf, Hom. No. Car., p. 6.
1916 Van Duzee, Check List Hem., p. 58, no. 1570.

Is common on black elder (*Sambucus canadensis* L.) in the lower parts of the valley, and has been taken on a variety of other hosts. An active insect, easily disturbed, but usually returning to its host after a short flight. Easily identified by the brown transverse bands.

The life history of this species has been followed from egg to adult on the black elder. The eggs are laid in the bark about the middle of August, in the second-year stems in deep slits. These eggs winter over and hatch about the middle of May. The earliest record for an adult is July 29, 1914, the period of development being unusually long due to the fact that the last nymphal instar is of extreme length. The adults are abundant during August and disappear about the last of September. In seasons in which warm weather occurred very late in the fall, the eggs have been known to hatch but the nymphs from these eggs did not survive the winter; and one brood a year is believed to be normal. The life history of this species may be best observed in Stations B and P.

Technical description.— Dark brown with transverse bands of yellowish white; suprahumeral horns stout and blunt; posterior process decurved; tegmina smoky hyaline.

Head broader than long, sculptured, basal part strongly and smoothly curved, front surface light yellow faintly marked with brown, faintly longitudinally ridged, very lightly or not at all punctate or pubescent; eyes prominent, extending beyond adjoining lateral margin of pronotum; ocelli shining, transparent, nearer to each other than to the eyes; sclerites of front projecting over clypeus at internal angles with a small hook; clypeus strong, swollen, roughly three-lobed, the central lobe the largest, tips strongly hirsute.

Pronotum densely and coarsely punctate; anterior surface slightly convex, light yellow with numerous brown markings, sparingly pubescent with rather long hairs; suprahumeral horns projecting outward and very slightly backward; lateral surfaces not pubescent, brown with two transverse light bands, the anterior broad and irregular in about center, the posterior narrower and regular just before apex of posterior process; posterior process gradually acute, extending beyond internal angles of tegmina.

Tegmina hyaline, tips smoky, bases opaque and lightly punctate; five apical and three discoidal cells. Undersurface of body very dark brown. Femora dark brown above; tibiae and tarsi ferruginous.

Length 9 mm.; width between humeral horns 5.5 mm.

5. *Ceresa bubalus* Fabr. (Plate XXIV, 3–11)

1794 *Membracis bubalus* Fabr., Ent. Syst. 4:14, no. 23.
1803 *Centrotus bubalus* Fabr., Syst. Rhyng., p. 20, no. 18.
1840 *Membracis bubalus* Blanch., Hist. Nat. Ins. 3:181.
1846 *Centrotus bubalus* Fairm., Rev. Memb., p. 286, no. 11.
1851 *Ceresa bubalus* Fitch, Cat. Ins. N. Y., p. 50.

1851 *Ceresa bubalus* Walk., List Hom. B. M., p. 531.
1851 Walk., List Hom. B. M., p. 1140.
1853 Harris, Hort. n. s. 3:283–284.
1853 Harris, Bost. Cult. 15:250.
1854 Emm., N. Y. Agr. Rept. 5:155, pl. 3.
1856 Fitch, Rept. Ins. N. Y. 3:355.
1856 Fitch, Rept. Ins. N. Y. 3:359.
1856 Fitch, Rept. Ins. N. Y. 3:390.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:335, 359, 390.
1858 Walk., List Hom. B. M. Suppl., p. 131.
1862 *Membracis bubalus* Uhler, Harris' Treatise, p. 221.
1862 *Ceresa bubalus* Fitch, Amer. Agr. 21:172.
1862 Fitch, Count. Gent. 19:335.
1862 Uhler, Harris' Treatise, p. 221.
1864 Fitch, Count. Gent. 23:386.
1867 Fitch, Rept. Ins. N. Y. 12:889.
1868 Walsh and Riley, Amer. Ent. 1:38.
1869 Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1869 Stål, Hem. Fab. 2:24.
1869 Stål, Bid. Memb. Kän., p. 245.
1869 Walsh and Riley, Amer. Ent. 1:250.
1870 Riley, Amer. Ent. and Bot. 2:245.
1872 Riley, Fourth Rept. Ins. Mo., p. 119.
1872 Riley, Amer. Agr. 31:302.
1873 Riley, Fifth Rept. Ins. Mo., p. 121–122, figs. 50–55.
1876 Uhler, List Hem. West Miss. River, p. 343.
1877 Glover, Rept. U. S. Dept. Agr., p. 29, fig. 15.
1877 Uhler, Rept. Hem. Colo. 1875, p. 456.
1877 Uhler, Wheeler's Rept. App. J, p. 1332.
1877 Butler, Cist. Ent. 2:215, no. 2.
1877 Lintner, Count. Gent. 42:463.
1878 Uhler, List Hem. Dak. and Mont., p. 509.
1878 Glover, MS. Journ. Hem., pl. 2, fig. 32.
1878 Glover, MS. Journ. Hom., pl. 1, fig. 29.
1880 Walton, Trans. Iowa Hort. Soc. 15:516.
1882 Riley, Amer. Nat. 16:822.
1882 Lintner, First Rept. Ins. N. Y., p. 284, 315, 331.
1883 Cooke, Ins. Inj. Farm, p. 71, figs. 33–35.
1883 Saunders, Ins. Inj. Fruits, p. 45, fig. 36.
1883 Popenoe, Rept. Kans. Hort. Soc., p. 196.
1883 Riley, Rural New-Yorker 42:411.
1883 Riley, Prairie Farmer 55:86.
1883 Osborn, Trans. Iowa Hort. Soc. 18:510–521.
1884 Osborn, Iowa Agr. Coll., Ent. Bul. 2:89.
1886 Marlatt, Kans. Acad. Sci. 10:84–85.
1886 Jack, Can. Ent. 18:21.
1886 Jack, Can. Ent. 18:51–54.
1886 Jack, Rept. Ent. Soc. Ont. 16:16.
1886 Prov., Petite Faune Can. 3:235.
1886 Osborn, The North West, p. 3.
1887 Jack, Rept. Ent. Soc. Ont. 17:18.
1887 Lintner, Rept. State Ent. N. Y. 4:266.
1888 Lintner, Fourth Rept. Ins. N. Y., p. 146.
1888 Comstock, Int. Ent., p. 171, fig. 141.
1889 Van Duzee, Can. Ent. 21:6.

1889 *Ceresa bubalus* Murtfeldt, Rept. Mo. Hort. Soc. 32:467.
1890 Lintner, Seventh Rept. Ins. N. Y., p. 360.
1890 Smith, Ins. N. J., p. 441.
1890 Weed, Ohio Agr. Exp. Sta. Bul. 2d ser:3:130.
1890 Packard, Ins. Inj. For. and Shade Trees, p. 335.
1890 Osborn, Orange Judd Farmer, p. 244.
1890 Weed, Ins. Life 3:4.
1890 Weed, Amer. Nat. 24:785.
1890 Weed, Ohio Agr. Exp. Sta. Rept. 9:58.
1890 Weed, Rept. Columbus Hort. Soc. 18:175.
1891 Weed, Insects and Insecticides, p. 36.
1891 Osborn, Orange Judd Farmer, p. 116.
1891 Osborn, Iowa Acad. Sci. 1²:128.
1891 Fletcher, Rept. Ent. and Bot. Can., p. 191.
1892 Weed, Amer. Gardener.
1892 Osborn, Trans. Iowa Hort. Soc. 27:119.
1892 Webster, Ohio Farmer, p. 258.
1892 Fitch, Rept. N. Y. St. Mus. 4:48.
1892 Fitch, Rept. N. Y. St. Ent. 9:30.
1892 Godg., Ins. Life 5:92.
1893 Webster, Rept. Ohio Hort. Soc. 26:68.
1893 Bruner, Rept. Nebr. Hort. Soc. 24:228.
1893 Murtfeldt, Rept. Mo. Hort. Soc. 36:116.
1893 Gillette, Colo. Agr. Exp. Sta. Rept. 6:55.
1893 Riley, Proc. Ent. Soc. Wash. 3:88–92.
1893 Riley, Ins. Life 6:206.
1893 Hopkins, W. Va. Agr. Exp. Sta. Bul. 32:230.
1893 Lintner, Eighth Rept. Ins. N. Y., p. 294.
1893 Osborn, Fr. and For. Tree Ins., p. 24, fig. 30.
1894 Murtfeldt, Colo. Rural World, March.
1894 Murtfeldt, Colo. Rural World, May.
1894 Godg., Cat. Memb. N. A., p. 401.
1894 Slingerland, Rural New-Yorker 53:297.
1894 Webster, Ohio Farmer, p. 409.
1894 Marlatt, Ins. Life 7:8–14.
1894 Bruner, Rept. Nebr. Hort. Soc. 25:162, 176.
1894 Murtfeldt, U. S. Dept. Agr., Ent. Bul. 32:38.
1895 Gillette and Baker, Hem. Colo., p. 65.
1896 Gillette, Colo. Agr. Exp. Sta. Rept. 9:147.
1896 Harvey, Maine Agr. Exp. Sta. Rept. 12:118.
1897 Marlatt, U. S. Dept. Agr., Bur. Ent. Cir. 23.
1897 Hillman, Nev. Agr. Exp. Sta. Bul. 36:38.
1898 Gillette, Colo. Agr. Exp. Sta. Bul. 47:64.
1899 Slingerland, Rural New-Yorker 58:362.
1899 Webster, Ohio Farmer, p. 318.
1899 Lintner, Fourteenth Rept., p. 317, 357, 365.
1900 Summers, Iowa Agr. Exp. Sta. Bul. 49:1–6.
1900 Green, Trans. Ill. Hort. Soc. 34:118.
1900 Popenoe, Kans. Agr. Exp. Sta. Bul. 99:52.
1900 Felt, Count. Gent., p. 281.
1900 Lugger, Minn. Agr. Exp. Sta. Bul. 69:106–110.
1901 Lockhead, Can. Hort. 34:221.
1902 Banks, U. S. Dept. Agr., Exp. Sta. Bul. 34:28.
1903 Washburn, Minn. Agr. Exp. Sta. Bul. 84:52.
1903 Washburn, Rept. St. Ent. Minn. 8:52.

PLATE XXIV

1, Dorsal outline of *Ceresa diceros* Say; 2, lateral outline of last nymphal instar

3, *Ceresa bubalus* Fabricius; 4, dorsal outline; 5, head; 6, frontal outline; 7, egg scars; 8, egg; 9, egg mass; 10, 11, last two nymphal instars

12, Dorsal outline of *Ceresa taurina* Fitch; 13, head; 14, frontal outline; 15, lateral outline of last nymphal instar

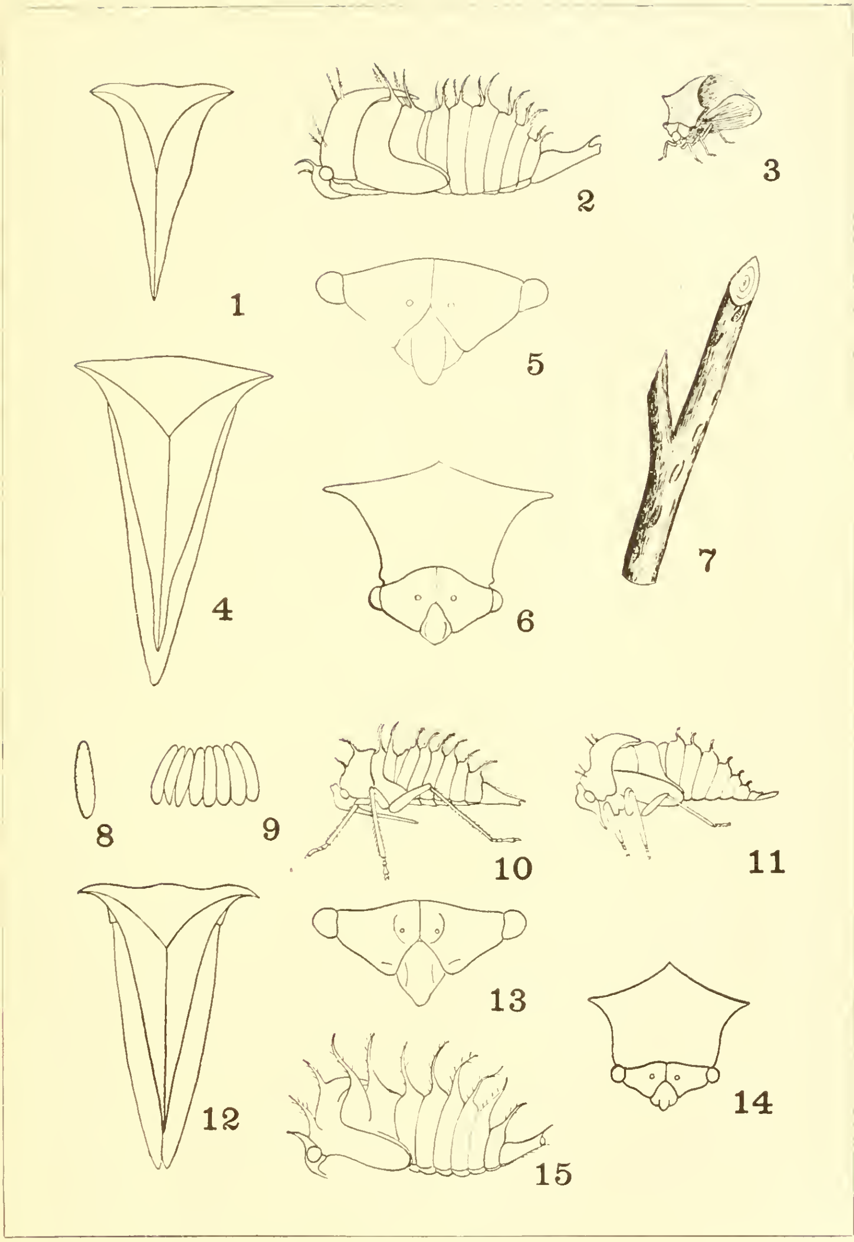


Plate XXIV

1903 *Ceresa bubalus* Buckt., Mon. Memb., p. 170, 220, 261, pl. 35, figs. 4, 4a.
1903 Cooley, Rept. St. Ent. Colo. 1:252.
1904 Felt, Rept. St. Ent. N. Y. 20:407.
1904 Felt, N. Y. St. Mus. Bul. 97:407.
1904 Pettit, Mich. Agr. Exp. Sta. Bul. 24:7.
1905 Felt, U. S. Dept. Agr., Bur. Ent. Bul. 52:51.
1905 Fletcher, Rept. Ent. Soc. Ont. 36:89.
1905 Kellogg, Amer. Ins., p. 169.
1906 Washburn, Minn. Agr. Exp. Sta. Bul. 100:47–48.
1907 Adams, Ark. Agr. Exp. Sta. Bul. 92:7.
1907 Swenk, Rept. Nebr. Ent., p. 21–22.
1907 Surface, Dept. Agr. Pa., Zool. Bul. 5:3, pl. 9.
1908 Swenk, Nebr. Hort. Soc. Bul. 19:17–19.
1908 Garman, Kans. Agr. Exp. Sta. Bul. 133:59, fig. 11.
1908 Van Duzee, Stud. N. A. Memb., p. 36.
1908 Washburn, Rept. St. Ent. Minn. 12:143.
1909 Van Duzee, Can. Ent. 41:380, 381.
1909 Webster, Journ. Econ. Ent. 2:212.
1909 Smith, Ins. N. J., p. 90.
1909 Sharp, Cambridge Nat. Hist. Ins. 2:577.
1909 Smith, Ins. Friends and Enem., p. 53, fig. 16.
1910 Matausch, Journ. N. Y. Ent. Soc. 18:165.
1910 Cooley, Rept. St. Ent. Mont. 7:53.
1910 Cooley, Mont. Agr. Exp. Sta. Bul. 79:53.
1910 Hodgkiss, Apple and Pear Memb., p. 92–100.
1911 Girault, Journ. N. Y. Ent. Soc. 19:15.
1911 Walden, Guide to Ins. Conn., pl. 3, fig. 25.
1912 Sand. and Jack., Elem. Ent., p. 123, fig. 168.
1912 Matausch, Bul. Amer. Mus. Nat. Hist. 31:331.
1913 Funkh., Hom. Wing Veins, figs. 38, 58.
1913 Reh, Handb. Pflanz., p. 637.
1913 Walden, Conn. Geo. and Nat. Hist. Surv. Bul. 16, pl. 3, fig. 25.
1913 Branch, Kans. Univ. Sci. Bul. 8:79, 100, figs. 5, 7, 10, 87.
1913 Baldwin, Rept. Ent. Ind. 6:70.
1913 Morrison, Rept. Ent. Ind. 6:121.
1913 Shelford, Anim. Comm., p. 265, fig. 259; p. 276, table 58.
1914 Van Duzee, Trans. S. Diego Soc. Nat. Hist. 2^1:48.
1915 Essig, Calif. Comm. Hort. 4:61–62.
1915 Metcalf, Hom. No. Car., p. 6.
1916 Van Duzee, Check List Hem., p. 58, no. 1572.

Very common on grasses and low shrubs. Widest range of hosts and localities of any membracid in the region. Nymphs feed on succulent herbs, particularly sweet clover (*Melilotus alba*); eggs are laid on young trees, particularly elm and apple. Adults are taken by sweeping and on the lower branches of trees. The largest of the local species of the genus. Injures stems by egg punctures. Recognized by its large size, broad, convex metopidium, and stout, short horns.

The life history of this species has been worked out in the basin on two distinct combinations of hosts — apple and aster, and elm and sweet

clover. In both cases the life of the insect is the same. The eggs are laid in the bark of stems two or three years old. The egg slits are peculiar (Plate XXIV, 7), being curved and parallel and so close together that the wound between them does not heal and thus considerable injury may be done to the twig. Oviposition occurs most commonly in early September. The process lasts about half an hour, during which time six or eight eggs are laid in the slit. These eggs winter over and hatch early in May. The young nymphs leave the tree on which the eggs were hatched and migrate to succulent weeds, sweet clover being in this locality the favorite host. About six weeks are required for complete development, each of the first four instars requiring approximately a week and the last instar two weeks. Ecdysis takes place on the main stem of the weed, usually near the top of the plant. The process requires about ten minutes. The early life of the adult is spent on the weeds and low herbs, but later the females migrate to the trees for egg-laying. Marlatt (1887) records the eggs of this species on weeds, but this has not been noted in the studies of the local forms. The species is of considerable economic importance because of the damage done to stems. Not only are the egg slits large enough to cause material mechanical damage, but the puncture allows the easy ingress of fungi and of other insects.

Technical description.— Bright green fading to yellowish in cabinet specimens; horns heavy and stout, pointing directly outward; metopidium broadly convex; dorsal crest high and regularly arched; posterior process slender and recurved; tegmina and hind wings entirely hyaline; clypeus heavy, stout, and bristled.

Head one-third broader than long, longitudinal striate sculpturing; basal part broadly curved, front surface yellow, not punctate nor pubescent; eyes prominent, dark brown, extending beyond lateral margin of pronotum adjoining; ocelli prominent, protruding, with brilliant orange borders, nearer to each other than to the eyes; clypeus strong, heavy, continuing lateral outline of face, apex bristled.

Pronotum densely and coarsely punctate; metopidium strongly convex, smooth impunctate areas above the eyes, sparingly pubescent with short scattered hairs; suprahumeral horns stout, blunt, projecting almost directly outward, not at all upward, tips often brownish, whitish line extending backward from tip to lateral margin; lateral surface marked with light-colored, semicircular impression; posterior process slender, depressed, extending halfway to apices of tegmina and slightly beyond tip of abdomen, apex brownish.

Tegmina hyaline, bases lightly punctate. Undersurface of body yellowish. Legs greenish.

Length to apices of tegmina, 10 mm.; width between horns, 6 mm.

6. *Ceresa taurina* Fitch (Plate XXIV, 12–15)

1835 *Membracis taurina* Harris, Cat. Ins. Mass., p. 579.
1835 Harris, Rept. Geol. Surv. Mass., p. 579.
1842 Harris, Treatise, p. 178.
1851 *Enchenopa taurina* Walk., List Hom. B. M., p. 495.

1856 *Ceresa taurina* Fitch, Rept. Ins. N. Y. 3:335.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:335.
1858 Walk., List Hom. B. M. Suppl., p. 131.
1862 *Membracis taurina* Harris, Treatise, p. 221.
1862 *Ceresa taurina* Uhler, Harris' Treatise, p. 221.
1869 Stal, Bid. Memb. Kän., p. 245.
1869 *Membracis taurinus* Rathvon, Momb. Hist. Lanc. Co. Pa., p. 550.
1877 *Ceresa taurina* Butler, Cist. Ent. 2:215, no. 3.
1882 Lintner, First Rept. Ins. N. Y., p. 133.
1884 Osborn, Iowa Agr. Coll., Ent. Bul. 2:90.
1886 Prov., Petite Faune Can. 3:235.
1890 Van Duzee, Psyche 5:388.
1892 Osborn, Trans. Iowa Hort. Soc. 27:119.
1893 Riley, Proc. Ent. Soc. Wash. 3:88–92.
1893 Riley, Ins. Life 6:206.
1893 Osborn, Fr. and For. Tree Ins., p. 24.
1894 Bruner, Rept. Nebr. Hort. Soc. 25:162.
1894 Godg., Cat. Memb. N. A., p. 403.
1894 Marlatt, Ins. Life 7:8–14.
1900 Green, Trans. Ill. Hort. Soc. 34:118.
1901 Howard, Ins. Book, p. 238, fig. 131.
1903 Buckt., Mon. Memb., p. 173.
1903 Buckt., Mon. Memb., p. 220, no. 39.
1904 Snow, Kans. Univ. Sci. Bul. 2:349.
1908 Washburn, Rept. St. Ent. Minn. 12:—.
1908 Surface, Dept. Agr. Pa., Zool. Bul. 6:38.
1908 Van Duzee, Stud. N. A. Memb., p. 37, pl. 1, fig. 19.
1909 Smith, Ins. N. J., p. 90.
1909 Sharp, Cambridge Nat. Hist. Ins. 2:577.
1910 Matausch, Journ. N. Y. Ent. Soc. 18:165.
1910 Hodgkiss, Apple and Pear Memb., p. 100–105.
1911 Girault, Journ. N. Y. Ent. Soc. 19:15.
1912 Matausch, Bul. Amer. Mus. Nat. Hist. 31:332, pl. 28, fig. 3.
1913 Reh, Handb. Pflanz., p. 637.
1913 Branch, Kans. Univ. Sci. Bul. 8:80, 100, figs. 8, 9.
1914 Bromley, Psyche 21:198.
1915 Funkh., Fitch's Types, p. 50.
1915 Metcalf, Hom. No. Car., p. 6.
1916 Van Duzee, Check List Hem., p. 58, no. 1576.

Common on fruit trees and bushes. Wide range of hosts. Often taken on apple, pear, raspberry, and blackberry. More abundant than *C. bubalus*. Recognized by the curved metopidium and the long, recurved horns. One of the commonest, and next to *C. bubalus* the largest, of the local Ceresas.

This species has been reared from eggs taken from apple and from pear. Locally the eggs are more numerous on the former host plant. In the field the insects may be reared from egg to adult on the tree if the branch containing the egg mass is covered with netting. Normally, however, the insects leave the tree after the second molt and drop to the ground, where they feed on small annuals. The eggs are laid in the buds

just under the outer bud scale. They are placed upright and close together, usually three or four in a row but sometimes singly. The tip of the egg projects from the bud and is easily visible to the naked eye. The eggs are laid about the first of September and winter over. The first nymphs are found the last week in April and reach maturity the last week in July. The first instar requires about eight days and the second seven, after which the nymphs migrate to weeds and bushes to feed. The insect shows as wide a range of feeding plants as any membracid in the basin and has been found on a large number of hosts. The second two instars require about seven and ten days, respectively, and the last over two weeks. These records agree fairly well with those obtained by Hodgkiss (1910:89) in his Geneva experiments. Only one brood a year is found locally, and the appearance of the nymphs and the adults is comparatively uniform from year to year. The species is abundant in most of the orchards of the basin.

Technical description.— Slightly smaller than the preceding species but resembling it in color; body slender and metopidium concave transversely; horns sharp, curving upward and backward.

Head roughly triangular, wider than long, roughly sculptured, not punctate nor pubescent, basal margin strongly curved; eyes prominent, brown and in some cases barred with darker, extending beyond the adjoining lateral margins of the pronotum; ocelli prominent, pearly, occasionally margined with reddish, nearer to each other than to the eyes; clypeus sub-rectangular, swollen and protruding, extending for half its length beyond lateral margin of face, faintly trilobed, apex bristled.

Pronotum deeply and coarsely punctured, bright green fading to yellow, sparingly pubescent; metopidium strongly concave with curved, transverse margin, area above eyes smooth; suprahumeral horns slender and sharp, extending upward and backward, often much curved, tips generally darker than bases; dorsal crest high and strongly curved; semicircular lateral impression deep and brownish; posterior process slender, strongly decurved, extending beyond apex of abdomen and halfway to tips of tegmina.

Tegmina and wings entirely hyaline. Underparts of body and legs yellow-green.

Length including tegmina, 9 mm.; width between tips of horns, 5.5 mm.

This species has often been confused in literature with *C. bubalus*, but is now recognized as entirely distinct.

7. *Ceresa constans* Walker (Plate xxv, 1, 2, 4)

1851	*Thelia constans*	Walk., List Hom. B. M., p. 563.
1869	*Ceresa constans*	Stål, Bid. Memb. Kän., p. 245.
1877		Butler, Cist. Ent. 2:215, no. 4.
1894		Godg., Cat. Memb. N. A., p. 404.
1903		Buckt., Mon. Memb., p. 173.
1908		Van Duzee, Stud. N. A. Memb., p. 37, pl. 1, figs. 7, 27.
1915		Metcalf, Hom. No. Car., p. 6.
1916		Van Duzee, Check List Hem., p. 58, no. 1577.

PLATE XXV

1, Dorsal outline of *Ceresa constans* Walker; 2, head; 4, frontal outline

3, Lateral outline of last nymphal instar of *Ceresa Palmeri* Van Duzee; 5, dorsal outline of adult; 6, head

7, Dorsal outline of *Ceresa borealis* Fairmaire; 8, head; 9, last nymphal instar

10, Dorsal outline of *Ceresa basalis* Walker; 11, head

12, Pronotum of *Stictocephala inermis* Fabricius; 13, head; 14, last nymphal instar

15, Pronotum of *Stictocephala lutea* Walker; 16, frontal outline; 17, head

18, Lateral outline of *Micrutalis calva* Say

19, Lateral outline of *Micrutalis dorsalis* Fitch

20, Lateral outline of *Acutalis tartarea* Say

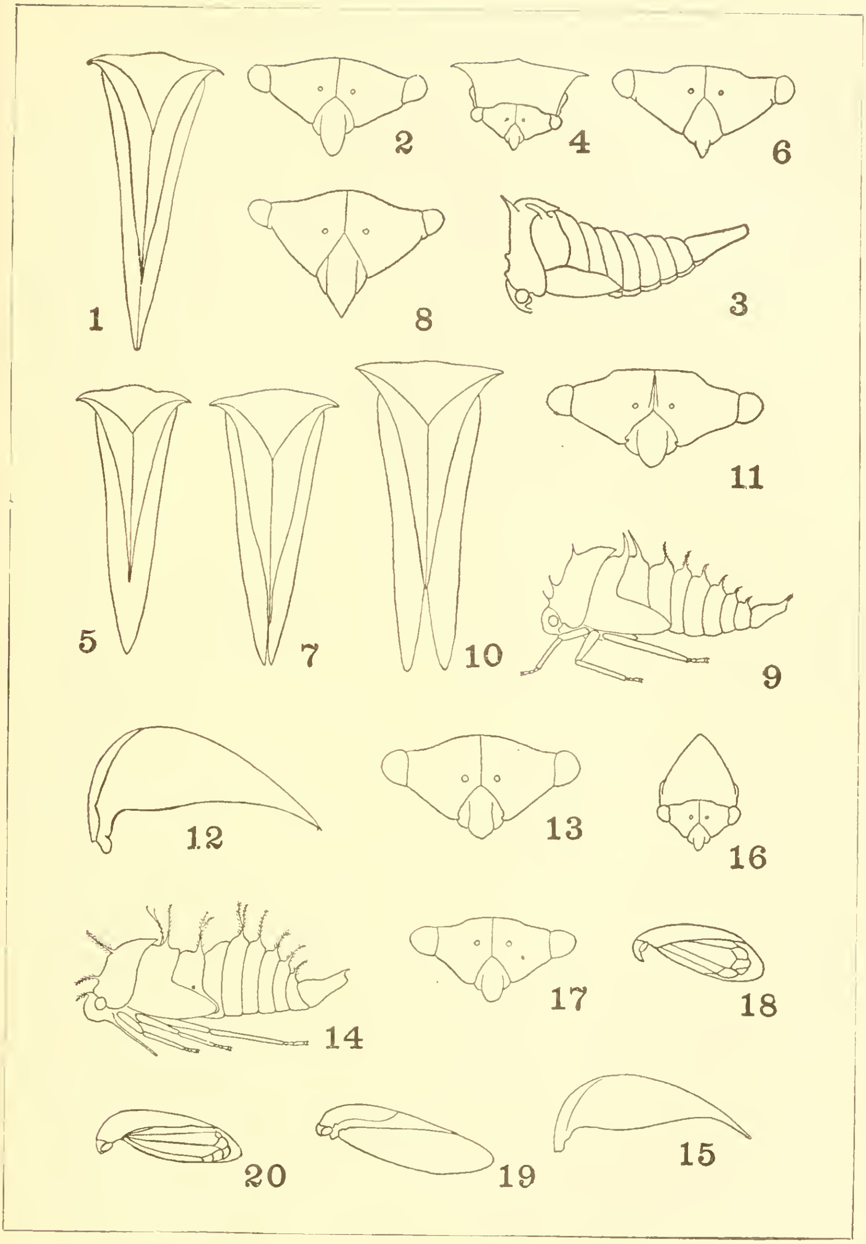


PLATE XXV

Comparatively common on locust. Seldom taken on any other host. Recognized by its small size, reddish carina, and long, recurved horns. The life history of this species is not known.

Technical description.— Small and distinctly reddish; dorsal crest low, median lateral line red; metopidium convex; horns sharp and much recurved; posterior process nearly straight, usually tipped with red; head triangular; tegmina and wings hyaline.

Head subtriangular, weakly sculptured, faintly longitudinally furrowed, very finely and lightly punctate, not pubescent; eyes prominent, dark brown with lighter edges, extending beyond adjoining lateral margins of pronotum; ocelli glassy, nearer to each other than to the eyes; clypeus much longer than wide, extending for more than half its length beyond lateral margin of face, tip hirsute.

Pronotum deeply and coarsely punctate, not pubescent, median carina prominent; dorsal crest low, rising but little higher than tips of suprahumeral horns; horns slender, sharp, much recurved, extending upward and curving backward; metopidium convex, regular; lateral semicircular impression deep, concolorous; posterior process nearly straight, not reaching the extremity of the abdomen and reaching barely one-third the distance to the tips of the tegmina.

Tegmina hyaline. Undersurface of body and legs yellowish.

Length 8 mm.; width 4 mm.

8. *Ceresa Palmeri* Van Duzee (Plate xxv, 3, 5, 6)

1908 *Ceresa Palmeri* Van Duzee, Can. Ent. 40:114.
1908 Van Duzee, Stud. N. A. Memb., p. 38, pl. 1, fig. 33.
1910 Matausch, Journ. N. Y. Ent. Soc. 18:166.
1912 Matausch, Bul. Amer. Mus. Nat. Hist. 31:332, pl. 28, fig. 4.
1915 Metcalf, Hom. No. Car., p. 6.
1916 Van Duzee, Check List Hem., p. 58, no. 1578.

Rather rare. Resembles *C. constans* in size and coloration but differs from that species in the shape of the pronotal horns. Close to *C. borealis* in general appearance but is smooth and not hairy. Has been taken only on young hickory. The newly emerged adults are very strongly marked with reddish.

A growth of small hickories along a little-used wagon road thru Coy's Glen produces this species each year, and both the eggs and the first nymphal stages have been found on these saplings. Attempts to rear the species in the field, however, have failed as the insects died after the second instar. Apparently the insect requires a second host as a feeding plant, but this host is not known. The first two instars in the cases in which records were obtained averaged five days for the first and six for the second.

Technical description.— Near the preceding species, but differing particularly in shape of suprahumeral horns, which are short, terete, and but little recurved; small, reddish species, with pronotum rather high, not pubescent.

Head wider than long, yellowish, only faintly sculptured, not punctate; eyes prominent, reddish with white borders, extending beyond adjoining lateral margins of pronotum; ocelli not prominent, pearly with reddish margins, nearer to each other than to the eyes; clypeus continuing lateral margin of face, swollen and pubescent at tip.

Pronotum yellow-green very strongly marked with brown and reddish; dorsal crest curved, strongly marked with red; lateral semicircular impression faint, area within it lighter in color than surrounding pronotum; posterior process slightly curved downward, about reaching tip of abdomen but not extending halfway to extremities of tegmina.

Tegmina hyaline, wrinkled, bases slightly punctate. Undersurface of body yellowish. Legs concolorous yellow-green in life, fading to pale yellow in cabinet specimens.

Length 8 mm.; width 3.5 mm.

9. *Ceresa borealis* Fairmaire (Plate xxv, 7–9)

1846	*Ceresa borealis*	Fairm., Rev. Memb., p. 284, no. 5.
1851		Walk., List Hom. B. M., p. 526.
1908		Van Duzee, Stud. N. A. Memb., p. 38, pl. 1, figs. 8, 32.
1909		Smith, Ins. N. J., p. 90.
1910		Matausch, Journ. N. Y. Ent. Soc. 18:166.
1913		Reh, Handb. Pflanz., p. 637.
1913		Funkh., Hom. Wing Veins, p. 82, fig. 5.
1915		Metcalf, Hom. No. Car., p. 6.
1916		Van Duzee, Check List Hem., p. 58, no. 1579.

The most abundant of the species of the genus in the basin. Found on a wide variety of plants and in a wide range of localities. Commonest on low shrubs and low trees. Close to *C. bubalus*, but smaller and darker and easily recognized by the very hairy pronotum.

This species has been reared in the laboratory from nymphs taken from pignut and fed on sweet clover. Hodgkiss (1910:107) reports the species as commonly ovipositing on apple and pear, but the orchards in the basin have shown very few instances of infection by *borealis*, while the eggs have been very abundant on pignut, hickory, young willow, and raspberry.

The eggs are laid in both the buds and the smaller twigs. As in *C. taurina*, the insect deposits the eggs in rows, with the tips projecting; but the number of eggs averages higher than in *C. taurina*, being from six to eight in a series. There appears to be one regular brood and part of a second each season. Some eggs are laid early, oviposition having been observed the first week in August. It continues until the last of September. Apparently the eggs first laid hatch the same season, but it is doubtful whether the adults from these eggs are successful in surviving the winter. The first nymphs have been observed in the field about the middle of April and by the first of May they are abundant. They have

not been reared in the field owing to the fact that, like most Ceresas, they require a change of feeding plant for development. In the insectary the nymphal stages averaged as follows:

First stage	5 days
Second stage	11 days
Third stage	9 days
Fourth stage	10 days
Fifth stage	12 days

The various individuals from the same egg cluster do not develop uniformly, some reaching maturity fully a week earlier than others; but adults are common in the field by the middle of June.

The species is found in all parts of the basin.

Technical description.— Resembling *C. bubalus* in general outline but much smaller and very hairy; metopidium convex; dorsum curved, posterior process only slightly decurved; head impunctate; notch of last ventral segment of female broad and triangular.

Head broader than long, yellowish, roughly sculptured, faintly longitudinally striate, not punctured nor pubescent; eyes prominent, mottled with green and brown, extending beyond adjoining lateral margins of pronotum; ocelli small, reddish, much nearer to each other than to the eyes; clypeus rounded, somewhat protruding, extending for more than half its length below lateral margin of face, tip hirsute.

Pronotum green, finely, deeply, and densely punctate, very hairy; metopidium convex; median carina faint; suprahumeral horns stout, blunt, nearly straight, projecting almost directly outward; dorsal crest regularly arcuate; lateral semicircular impression nearly obsolete; posterior process curving slightly downward, not extending beyond tip of abdomen and reaching only for a short distance beyond internal angles of tegmina.

Tegmina entirely hyaline, somewhat wrinkled, bases lightly punctate. Legs and undersurface of body concolorous greenish.

Length 8 mm.; width 4 mm.

10. *Ceresa basalis* Walker (Plate xxv, 10, 11)

1851 *Ceresa basalis* Walk., List Hom. B. M., p. 527.
1869 Stål, Bid. Memb. Kän., p. 245.
1877 Butler, Cist. Ent. 2:215, no. 5.
1893 *Ceresa melanogaster* Osborn, Bul. Nat. Hist. Lab. Iowa St. Mus. 2:390.
1894 *Ceresa basalis* Godg., Cat. Memb. N. A., p. 404.
1894 *Ceresa turbida* Godg., Cat. Memb. N. A., p. 406.
1895 Gillette and Baker, Hem. Colo., p. 66.
1903 *Stictocephala semi-brunnea* Buckt., Mon. Memb., p. 174, pl. 36, fig. 6.
1905 *Ceresa turbida* Van Duzee, N. Y. St. Mus. Bul. 97:552.
1908 *Ceresa basalis* Van Duzee, Stud. N. A. Memb., p. 39, pl. 1, fig. 34.
1908 Van Duzee, Can. Ent. 40:114.
1909 Smith, Ins. N. J., p. 90.
1916 Van Duzee, Check List Hem., p. 58, no. 1580.

Common. About the size of *C. borealis* but not so hairy. Easily recognized by the black undersurface of the body, which is a sufficient

specific character. Taken in gardens on cultivated plants, and occasionally on low shrubs growing wild.

This insect has been observed ovipositing on rosebushes during the middle of September, and nymphs from these eggs appeared on July 1 of the following year. An attempt to rear these nymphs in the laboratory, however, was unsuccessful owing to failure to discover a satisfactory food plant. Since adults are not common in the field before the middle of August, it appears that the species is one of the later forms of the genus, the eggs being laid later in the season and the nymphs and adults being correspondingly retarded. So far as is known there is but one brood in a season.

The species is most abundant in Stations C and P.

Technical description.— Much resembling the preceding species, but differing in coloration and not so hairy; undersurface of body black, the dark coloration often extending over face and femora; metopidium nearly flat, dorsal crest low; posterior process slightly curved downward.

Head broader than long, very irregular in outline, roughly sculptured, not punctured nor pubescent; eyes prominent, grayish, extending as far outward as humeral angles; ocelli distinct, reddish, nearer to each other than to the eyes; clypeus irregular, swollen and hairy at apex.

Pronotum finely and deeply punctate, very hairy; humeral angles prominent; suprahumeral horns short, stout, blunt, horizontal, not projecting upward or backward; dorsal crest convex but not high; semicircular impression distinct but concolorous; posterior process slender, slightly decurved, extending beyond extremity of abdomen but not more than one-third the distance from internal angles to tips of tegmina.

Tegmina hyaline, somewhat wrinkled, apical veins often tinged with brown, bases lightly punctate. Undersurface of body black; abdomen black below and segments often bordered with black; underparts of head and entire femora usually black or brown.

Length 7.5 mm.; width 3.5 mm.

The genus Stictocephala Stål

The two local species of the genus Stictocephala may be distinguished as follows:

Size large; color uniform green .... inermis
Size small; undersurface of body black .... lutea

Both species are common and they are about equal in numbers. Both are more or less grass-inhabiting, and are more abundant in the lower parts of the valley than in the upper.

11. *Stictocephala inermis* Fabricius (Plate xxv, 12–14)

1775 *Membracis inermis* Fabr., Syst. Ent. 4:678, no. 1.
1781 Fabr., Spec. Ins. 2:318, no. 16.

1787 *Membracis inermis* Fabr., Mant. Ins. 2:265, no. 26.
1792 Oliv., Enc. Méth., p. 663, no. 10.
1794 Fabr., Ent. Syst. 4:15, no. 30.
1831 *Membracis goniphora* Say, Journ. Acad. Nat. Sci. Phila. 5:243.
1851 *Ceresa gonophora* Walk., List Hom. B. M., p. 1141.
1851 *Smilia incrmis* Fitch, Cat. Ins. N. Y., p. 48.
1856 Fitch, Rept. Ins. N. Y. 3:360, 471.
1859 *Membracis goniphora* Say, Compl. Writ. 2:377.
1869 *Stictocephala inermis* Stål, Bid. Memb. Kän., p. 246.
1869 Stal, Hem. Fab. 2:33.
1869 *Smilia inermis* Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1877 *Stictocephala inermis* Glover, Rept. U. S. Dept. Agr., p. 30, fig. 19
1878 Glover, MS. Journ. Hom., pl. 2, fig. 34.
1878 Uhler, List Hem. Dak. and Mont., p. 509.
1882 Lintner, First Rept. Ins. N. Y., p. 284.
1886 Prov., Petite Faune Can. 3:237.
1890 Smith, Ins. N. J., p. 441.
1890 Van Duzee, Psyche 5:389.
1891 *Stictocepahala inermis* Osborn, Iowa Acad. Sci. 1²:128.
1892 *Stictocephala inermis* Van Duzee, Rept. N. Y. St. Ent. 9:410
1892 Riley, Ins. Life 5:19.
1892 Godg., Ins. Life 5:92.
1895 Gillette and Baker, Hem. Colo., p. 67.
1903 Felt, Rept. N. Y. For. Fish and Game Comm. 7:687.
1903 Buckt., Mon. Memb., p. 174, pl. 36, figs. 5–5b.
1904 Snow, Kans. Univ. Sci. Bul. 2:349.
1908 Van Duzee, Stud. N. A. Memb., p. 44.
1909 Smith, Ins. N. J., p. 91.
1909 Webster, Journ. Econ. Ent. 2:193.
1911 Osborn, Journ. Econ. Ent. 4:139.
1913 Branch, Kans. Univ. Sci. Bul. 8:101, figs. 16, 17, 66, 89.
1914 Van Duzee, Trans. S. Diego Soc. Nat. Hist. 2¹:48.
1915 Metcalf, Hom. No. Car., p. 7.
1916 Van Duzee, Check List Hem., p. 58, no. 1587.

Common on sweet clover and red clover, and occasionally on timothy. Rarely on low shrubs and the low branches of trees, particularly apple. At once recognized by its large size, concolorous light green body, and broad metopidium. Is very active and flies well. Somewhat destructive to host plants by girdling stems.

It is interesting to note that this species, which is the most abundant representative of its genus in the basin, has not been found on alfalfa, the chief host plant of the genus in the South. It may be noted in the same connection that most species of the Membracidae which are common on alfalfa in the southern and western parts of the country change to sweet clover in the North or are represented on sweet clover by their nearest relatives. Whether this is due to the difference in the varieties of alfalfa grown in the different regions is a matter of conjecture.

The eggs are laid in the young stems of apple just beneath the bark, in groups of four or five. The egg puncture is a ragged one and fails to heal smoothly, leaving a characteristic scar which has been well figured by Hodgkiss (1910:98). Oviposition occurs over an extended period during July, August, and September. The eggs winter over and hatch about the first of May. Almost immediately the nymphs migrate to sweet clover, where they spend the most of their lives, the mature females returning to the apple only to oviposit.

The life history of a closely related species, *S. festina*, has been carefully worked out by Wildermuth (1915), who finds the eggs laid in the stems of alfalfa. If this is true in the case of sweet clover it has not been discovered by careful search. Since the clover dies down during the winter and there is no evidence of the adults' wintering over, this theory does not seem tenable.

Technical description.— Fine large species, brilliant green slowly fading to yellowish in dried material; metopidium perpendicular; dorsal crest high and arcuate; posterior process slender and curving downward; tegmina and wings entirely hyaline; upper parts of femora often marked with black.

Head broad, nearly smooth, very finely and faintly punctate, longitudinally striate; eyes prominent, subtriangular, very dark bordered with white, extending beyond adjoining lateral margins of pronotum; ocelli prominent, brownish, nearer to each other than to the eyes; inferior margins of vertex broadly sinuate; clypeus broad, sparingly pubescent, median lobe of apex extending below lateral lobes.

Pronotum densely and coarsely but not deeply punctured; metopidium convex, median carina distinct but irregular; sides of metopidium meeting before middle of body; lateral semicircular impression deep; posterior process long, slender, gradually acuminate, curving downward, extending beyond abdomen and reaching about halfway from internal angles to apices of tegmina.

Tegmina entirely hyaline, slightly wrinkled, bases greenish and lightly punctured. Undersurface of body yellowish; segments of abdomen in some cases bordered with black; notch of last ventral segment of female broadly angular. Femora often marked with black above; tarsi ferruginous.

Length to tips of tegmina, 9 mm.; width between humeral angles, 4 mm.

12. *Stictocephala lutea* Walker (Plate xxv, 15–17)

1851 *Thelia lutea* Walk., List Hom. B. M., p. 559.
1851 *Thelia inermis* Walk., List Hom. B. M., p. 1142.
1854 *Gargara pectoralis* Emm., N. Y. Agr. Rept. 5:157, pl. 13, fig. 12.
1869 *Stictocephala lutea* Stål, Hem. Fab. 2:24.
1869 Stål, Bid. Memb. Kän., p. 247.
1892 Godg., Ins. Life 5:92.
1894 Godg., Cat. Memb. N. A., p. 410.
1903 Buckt., Mon. Memb., p. 174.
1903 Buckt., Mon. Memb., p. 195, pl. 42, fig. 7.
1903 Buckt., Mon. Memb., p. 219, no. 16.
1905 Van Duzee, N. Y. St. Mus. Bul. 97:552.

1908	*Stictocephala lutea*	Van Duzee, Stud. N. A. Memb., p. 49, pl. I, figs. 14, 31.
1909		Smith, Ins. N. J., p. 91.
1910		Matausch, Journ. N. Y. Ent. Soc. 18:166.
1911		Osborn, Journ. Econ. Ent. 4:139.
1913		Branch, Kans. Univ. Sci. Bul. 8:102, figs. 28, 29, 90.
1913		Shelford, Anim. Comm., p. 298.
1913		Funkh., Hom. Wing Veins, fig. 31.
1914		Van Duzee, Can. Ent. 46:388.
1915		Metcalf, Hom. No. Car., p. 7.
1916		Van Duzee, Check List Hem., p. 59, no. 1598.

Commonest on trees, particularly oaks. Less common on grasses, in which respect it differs from the preceding species. Recognized by the dark under-thorax and femora, and by the small size.

The nymphs of this species have not been distinguished. In a number of instances nymphs that were thought to be those of *S. lutea* have been found on small oak seedlings, but attempts to rear them proved unsuccessful.

Technical description.— Small species; grass-green above, usually marked with black below; metopidium sloping, dorsal crest not high, not regularly arcuate; tegmina smoky hyaline.

Head perpendicular, subtriangular, broader than long, finely punctate, sparingly pubescent, weakly sculptured; eyes prominent, brown usually banded with reddish, extending outward as far as lateral angles; ocelli distinct, yellowish margined with brown, much nearer to each other than to the eyes; inferior margins of vertex weakly sinuate, their ventral mesal angles ending in hooks; clypeus robust, extending only slightly beyond inferior margins of vertex.

Pronotum closely and deeply punctate; metopidium convex, median carina faint, smooth yellowish area on each side near base of head, sides of metopidium meeting at or a little before middle of body; dorsal crest not high, sloping gradually from junction of carinate edges of metopidium to posterior process; semicircular lateral impression weak; posterior process slender, gradually acute, extending as far as tip of abdomen and to a point on tegmina half-way between internal angles and apices.

Tegmina hyaline, smoky at apices. Underparts of thorax distinctly black. Legs generally marked with black. Notch of last ventral segment of female very small or obsolete.

Length 6.5 mm.; width 2 mm.

The working-out of the life history of this species is one of the problems that remain unsolved. Oviposition has never been observed and the nymphs have not been positively identified. Its general life habits seem to be quite different from those of *S. inermis*.

The genus Acutalis Fairmaire

The genus Acutalis contains a limited number of small species, only one of which is represented in the fauna of the Cayuga Lake Basin. The genus is characterized by the small size of the insects, the dark colors of the prothorax, and the five apical cells of the tegmina set off by distinct veins.

13. *Acutalis tartarea* Say (Plate xxv, 20)

1831 *Membracis tartarea* Say, Journ. Acad. Nat. Sci. Phila. 5:242.
1851 *Ceresa tartarea* Walk., List Hom. B. M., p. 1141.
1859 *Membracis tartarea* Say, Compl. Writ. 2:376.
1876 *Acutalis tartarea* Uhler, List Hem. West Miss. River, p. 345.
1886 *Ceresa semicrema* Prov., Petite Faune Can. 3:235.
1886 *Membracis tartarea* Prov., Petite Faune Can. 3:236.
1890 *Acutalis tartarea* Van Duzee, Psyche 5:389.
1894 Godg., Cat. Memb. N. A., p. 427.
1908 Van Duzee, Stud. N. A. Memb., p. 51.
1909 Smith, Ins. N. J., p. 91.
1913 Funkh., Hom. Wing Veins, fig. 32.
1913 Branch, Kans. Univ. Sci. Bul. 8:102, figs. 18, 19, 80.
1915 Metcalf, Hom. No. Car., p. 5.
1916 Van Duzee, Check List Hem., p. 59, no. 1602.

Very rare. Only one record for the basin. This specimen collected on July 20, 1886, by G. McCargo, and now in the Cornell University collection.

Technical description.— Small elongate species, very black, with eyes, undersurface of body, and in some cases lateral margins of pronotum white, apices of tegmina abruptly hyaline.

Head twice as broad as long, densely black, smooth, not punctate nor pubescent; eyes prominent and white; ocelli small, white, about equidistant from each other and from the eyes; clypeus foreshortened, smooth, extending only slightly in a semicircular curve below inferior line of face.

Pronotum intensely black above, finely punctate, not pubescent, lateral margins and tip of posterior process in some cases marked with white; dorsal crest low, weakly convex; posterior process nearly straight, slightly decurved, more or less tectiform, extending beyond abdomen and almost to end of apical cells of tegmina but not reaching apex of hyaline border.

Tegmina opaque black for basal two-thirds, apical third suddenly hyaline; veins heavy and black; wide apical border; basal third punctate. Undersurface of body pale. Legs yellowish, tarsi fuscous.

Length to apices of tegmina, 4.5 mm.; width between humeral angles, 2 mm.

The genus Micrutalis Fowler

The genus Micrutalis is closely related to Acutalis but is distinguished by having four apical cells in the tegmina with the veins very obscure. Both Acutalis and Micrutalis are common in the southeastern part of the State, but few forms are found in the Cayuga Lake Basin.

14. *Micrutalis dorsalis* Fitch (Plate xxv, 19)

1851 *Tragopa dorsalis* Fitch, Cat. Ins. N. Y., p. 52.
1851 Walk., List Hom. B. M., p. 1147.
1856 *Acutalis dorsalis* Fitch, Rept. Ins. N. Y. 3:390.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:390.
1869 Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.

1876 *Acutalis dorsalis* Uhler, List Hem. West Miss. River, p. 345.
1883 Saunders, Ins. Inj. Fruits, p. 289.
1890 Van Duzee, Psyche 5:391.
1892 Godg., Ins. Life 5:92.
1894 Godg., Cat. Memb. N. A., p. 428.
1900 Lugger, Minn. Agr. Exp. Sta. Bul. 69:112-113.
1903 *Horiola dorsalis* Buckt., Mon. Memb., p. 158.
1908 *Micrutalis dorsalis* Van Duzee, Stud. N. A. Memb., p. 53.
1909 Smith, Ins. N. J., p. 91.
1913 Funkh., Hom. Wing Veins, fig. 34.
1915 Funkh., Fitch's Types, p. 50.
1916 Van Duzee, Check List Hem., p. 59, no. 1604.

Apparently rare. Only two records for the basin — one August 3, 1889, and one August 13, 1895. Both specimens are in the Cornell University collection. Careful collecting for Membracidae during the past seven years has failed to yield further specimens.

Technical description.— About the size of the preceding species and resembling it in general structure; anterior dorsal part of pronotum black, posterior and lateral parts white; tegmina and hind wings entirely hyaline, veins very indistinct, tegmina with four apical areas.

Head twice as wide as long, smooth, not punctate, not pubescent, upper half jet black, lower half suddenly pale cream-colored; eyes prominent and gray; ocelli very minute, pearly, sunk in depressions, about equidistant from each other and from the eyes; clypeus rounded, cream-colored marked with two brown lines; rounded depression in vertex on either side of clypeus.

Pronotum low, rounded, no median carina, sparingly punctate, not pubescent; anterior dorsal surface black, posterior half and most of lateral margin creamy white; posterior process heavy, flat, gradually acute, not reaching extremity of abdomen.

Tegmina hyaline, veins very indistinct. Entire abdomen yellowish. Undersurface of thorax black. Femora dark brown or black; tibiae and tarsi fuscous.

Length 5 mm.; width 2.5 mm.

15. *Micrutalis calva* Say (Plate xxv, 18)

1831 *Membracis calva* Say, Journ. Acad. Nat. Sci. Phila. 5:242.
1834 *Membracis melanogramma* Perty, Del. An. Art., pl. 35, fig. 10.
1835 *Smilia flavipennis* Germ., Silb. Rev. 3:240.
1846 *Acutalis flavipennis* Fairm., Rev. Memb., p. 497, no. 5.
1846 *Membracis melanogramma* Fairm., Rev. Memb., p. 497.
1851 *Ceresa calva* Walk., List Hom. B. M., p. 1111.
1851 *Acutalis flavipennis* Walk., List Hom. B. M., p. 591.
1851 *Acutalis melanogramma* Walk., List Hom. B. M., p. 591.
1856 *Acutalis calva* Fitch, Rept. Ins. N. Y. 3:391.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:391.
1859 *Membracis calva* Say, Compl. Writ. 2:376.
1876 *Acutalis calva* Uhler, List Hem. West Miss. River, p. 345.
1878 Glover, MS. Journ. Hom., pl. 1, fig. 3.
1886 *Ceresa calva* Prov., Petite Faune Can. 3:236.
1890 *Acutalis calva* Van Duzee, Psyche 5:389.
1892 Godg., Ins. Life 5:92.
1893 *Acutalis Illinoiensis* Godg., Can. Ent. 25:53.
1894 *Acutalis calva* Godg., Cat. Memb. N. A., p. 428.

1895 *Acutalis calva* Gillette and Baker, Hem. Colo., p. 67.
1907 *Micrutalis Illinoiensis* Baker, Can. Ent. 39:116.
1907 *Micrutalis calva* Baker, Can. Ent. 39:116.
1908 Van Duzee, Stud. N. A. Memb., p. 53.
1908 *Micrutalis Illinoiensis* Van Duzee, Stud. N. A. Memb., p. 53.
1909 *Micrutalis calva* Van Duzee, Flor. Hem., p. 206.
1909 Smith, Ins. N. J., p. 91.
1910 Matausch, Journ. N. Y. Ent. Soc. 18:167.
1912 Matausch, Psyche 19:66.
1913 Funkh., Hom. Wing Veins, fig. 33.
1913 Branch, Kans. Univ. Sci. Bul. 8:103, figs. 20, 21, 82.
1915 *Micrutalis Illinoiensis* Metcalf, Hom. No. Car., p. 6.
1915 *Micrutalis calva* Metcalf, Hom. No. Car., p. 6.
1916 Van Duzee, Check List Hem., p. 59, no. 1605.

Another more southern form that has been found once in the basin. A single specimen was collected by the author from a young locust tree (*Robinia pseudacacia*) in August, 1911, in the bed of Six Mile Creek. The species is easily distinguished by its very small size and shining black prothorax.

Technical description.— Very minute; one of the smallest species of Membracidae in the United States; usually strongly marked with black altho color is variable; abdomen yellowish; tegmina hyaline, veins very indistinct.

Head broad, smooth, lightly punctate, not pubescent, upper third black, lower two-thirds yellowish; eyes prominent, white or gray; ocelli not prominent, pearly, about equidistant from each other and from the eyes and situated slightly above an imaginary line drawn thru centers of eyes; clypeus rounded, continuing sinuate outline of inferior margin of face.

Pronotum low, nearly flat, finely punctate, not pubescent, anterior part usually black, tip of posterior process generally pale; posterior process stout, triangular, just reaching internal angles of tegmina and not extending as far as tip of abdomen.

Tegmina entirely hyaline, not punctate nor pubescent at base, veins indistinct, apical border broad. Entire abdomen pale; undersurface of thorax often marked with black. Femora black or ferruginous; tibiae fuscous, tarsi ferruginous.

Length 3-3.5 mm.; width 1.5-1.7 mm.

The genus Carynota Fitch

The two species of the genus Carynota represented in this basin may be separated by the fact that one (*C. mera*) is large and gray with a transverse lateral band of black, while the other (*C. porphyrea*) is small and brown with a sprinkling of light points on either side of the pronotum.

16. *Carynota mera* Say (Plate XXVI, 1-3)

1831 *Membracis mera* Say, Journ. Acad. Nat. Sci. Phila. 5:310.
1851 *Carynota mera* Fitch, Cat. Ins. N. Y., p. 48.
1851 Walk., List Hom. B. M., p. 1144.
1854 *Gargara majus* Emm., N. Y. Agr. Rept. 5:156, pl. 13, fig. 6
1856 *Ophiderma mera* Fitch, Rept. Ins. N. Y. 3:465.

PLATE XXVI

1, Pronotum of *Carynota mera* Say; 2, head; 3, last nymphal instar
4, Lateral outline of *Carynota porphyrea* Fairmaire
5, *Thelia bimaculata* Fabricius; 6, last nymphal instar
7, Lateral outline of *Glossonotus acuminatus* Fabricius
8, Lateral outline of *Glossonotus univittatus* Harris
9, Pronotum of *Glossonotus crataegi* Fitch; 10, frontal outline
11, Pronotum of *Heliria scalaris* Fairmaire; 12, frontal outline
13, Pronotum of *Telamona declivata* Van Duzee
14, Pronotum of *Telamona pyramidata* Uhler
15, Pronotum of *Telamona barbata* Van Duzee
16, Pronotum of *Telamona obsoleta* Ball
17, Pronotum of *Telamona Westcotti* Goding

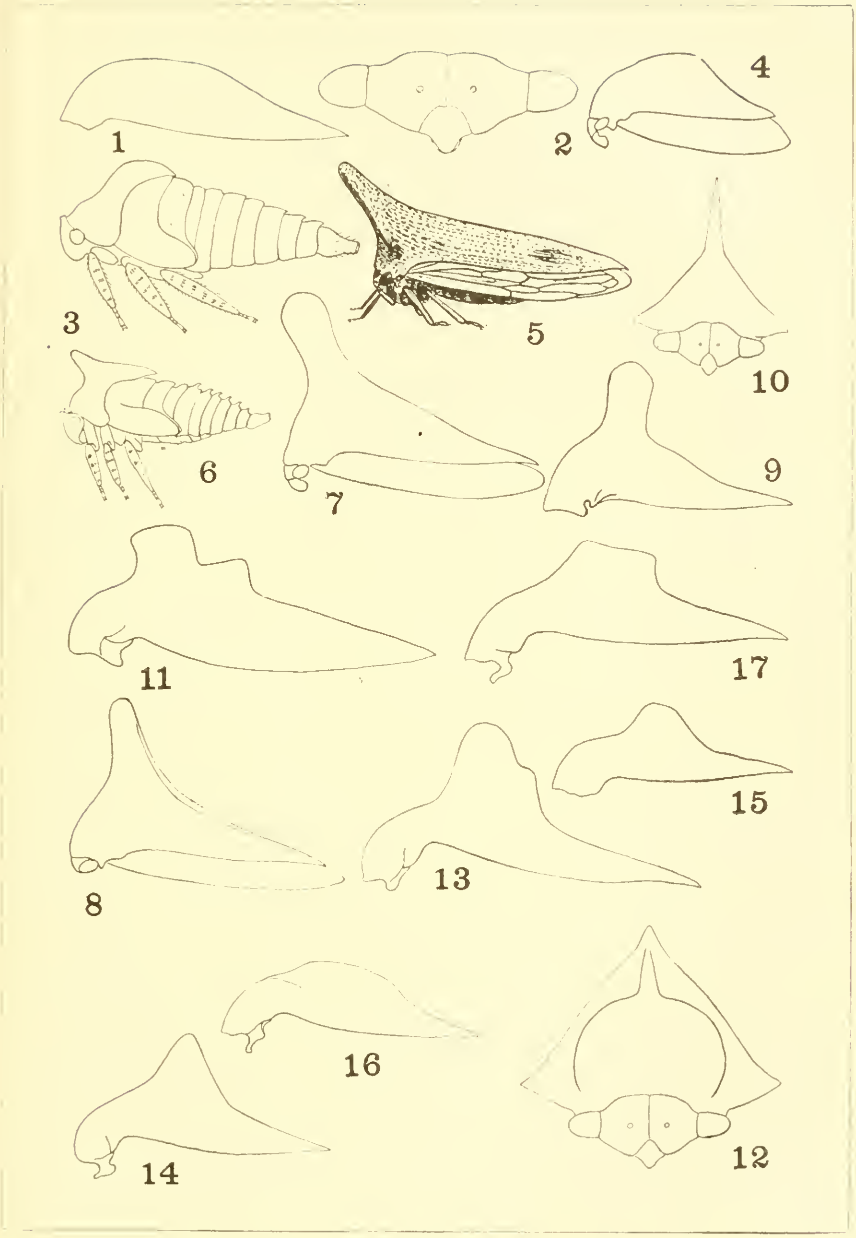


Plate XXVI

1856	*Ophiderma mera*	Fitch, Trans. N. Y. Agr. Soc. 16:465.
1859	*Membracis mera*	Say, Compl. Writ. 2:379.
1869	*Ophiderma mera*	Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1878		Glover, MS. Journ. Hom., pl. 1, fig. 16.
1886	*Carynota mera*	Prov., Petite Faune Can. 3:246.
1890		Van Duzee, Psyche 5:389.
1890	*Ophiderma mera*	Smith, Ins. N. J., p. 442.
1890		Packard, Ins. Inj. For. and Shade Trees, p. 342.
1891		Osborn, Iowa Acad. Sci. 1^{2}:128.
1892	*Carynota mera*	Godg., Ins. Life 5:93.
1894		Godg., Cat. Memb. N. A., p. 443.
1894	*Carynota strombergi*	Godg., Cat. Memb. N. A., p. 443.
1908	*Carynota mera*	Van Duzee, Stud. N. A. Memb., p. 56.
1909		Smith, Ins. N. J., p. 91.
1910		Matausch, Journ. N. Y. Ent. Soc. 18:167.
1911		Matausch, Journ. N. Y. Ent. Soc. 19:195.
1912		Matausch, Bul. Amer. Mus. Nat. Hist. 31:332.
1913		Funkh., Hom. Wing Veins, figs. 35, 59.
1915		Metcalf, Hom. No. Car., p. 7.
1916		Van Duzee, Check List Hem., p. 59, no. 1609.

Common on hickory and butternut; rarer on oak. More abundant in the higher parts of the hills. Large collections have been made in the neighborhood of West Danby. Distinguished by its large size and conspicuous color pattern. This species, which is common on pecan in the South, adopts hickory and butternut for its northern hosts.

The eggs are laid in the buds, at the base of the buds, and in the younger stems in late summer and early fall. The season for oviposition seems to be somewhat extended, the field notes showing records ranging from August 12 to September 30. The nymphs appear about the middle of June. Nymphs hatching on June 17 and covered with netting successfully reached maturity from July 22 to August 1 in the field without change of host. The duration of each instar was not ascertained. No attempt has been made to rear the species in the insectary owing to the difficulty of transplanting hickory and butternut seedlings.

The species is most abundant in Stations M, N, O, and P.

Technical description.— Fine large species; gray marked with dark brown and chestnut; pronotum convex and elevated; tegmina fuscous-hyaline tipped with dark brown.

Head nearly twice as broad as long, uniform light gray, very distinctly punctate, sparingly pubescent with short white hairs; eyes very prominent and brown; ocelli prominent, pearly, margined with orange, somewhat protruding, nearer to each other than to the eyes; clypeus subtriangular, continuing inferior outline of face, tip produced in small tooth, hirsute.

Pronotum gray, finely punctate pubescent, median carina percurrent; metopidium convex, irregular brown mark above internal angle of each eye; dorsal line arcuate, suddenly depressed before posterior process in female, depression not so evident in male; wide, dark brown, transverse band crossing middle of pronotum on each side; posterior process heavy, pointed, tip chestnut.

Tegmina smoky hyaline, veins prominent, bases punctate especially along veins and at costal margins, tips dark brown or black. Legs and undersurface of body ferruginous.
Length: female, 10 mm.; male, 8.5 mm. Width: female, 5 mm.; male, 4 mm.

17. *Carynota porphyrea* Fairmaire (Plate xxvi, 4)

1846 *Thelia porphyrea* Fairm., Rev. Memb., p. 306, no. 4.
1851 Walk., List Hom. B. M., p. 555.
1867 *Optilete porphyrea* Stål, Bid. Memb. Syst., p. 556, pl. 2, fig. 22.
1878 Glover, MS. Journ. Hom., pl. 2, fig. 22.
1908 *Carynota porphyrea* Van Duzee, Stud. N. A. Memb., p. 57.
1915 Metcalf, Hom. No. Car., p. 7.
1916 Van Duzee, Check List Hem., p. 59, no. 1614.

Scarce. Occasionally taken on oak. Much smaller and shorter than the preceding species and easily separated by its color.

Technical description.— Smaller than preceding species; dorsum higher and more arched; brilliant chestnut in color with irregular yellow markings.

Head triangular, brightly marked with red and yellow patches, sculptured, finely punctate, sparingly pubescent; eyes prominent and black; ocelli not prominent, pearly, nearer to each other than to the eyes; clypeus red with obsolete median yellow line; inferior margin of face strongly sinuate.

Pronotum chestnut, irregularly dotted with yellow, broad transverse yellow band at base of posterior process, coarsely punctate, sparingly pubescent on anterior surface; dorsum elevated, middle of elevation high and arcuate, sudden depression before posterior process; on each side an indentation at about center; posterior process short, thick, heavy, tectiform, not reaching apices of tegmina.

Tegmina smoky hyaline, veins prominent, bases and costal margins punctate, tips clouded with chestnut. Undersurface of body chestnut. Legs ferruginous.
Length 8 mm.; width 4 mm.

The genus Thelia A. & S.

Only one species of the genus Thelia is represented in the Cayuga Lake Basin, but this species is so common that it ranks second in abundance of all the Membracidae of the region.

18. *Thelia bimaculata* Fabricius (Plate xxvi, 5, 6)

1794 *Membracis bimaculata* Fabr., Ent. Syst. 4:10, no. 11.
1799 Coq., Ill. Io. 1:pl. 8, fig. 1.
1803 Fabr., Syst. Rhyng., p. 14, no. 37.
1842 Harris, Treatise, p. 178, 179.
1843 *Thelia bimaculata* A. & S., Hem., p. 541.
1846 Fairm., Rev. Memb., p. 312, no. 21.
1851 Walk., List Hom. B. M., p. 566.
1851 Walk., List Hom. B. M., p. 1142.
1851 Fitch, Cat. Ins. N. Y., p. 52.
1851 *Thelia unanimis* Walk., List. Hom. B. M., p. 566.
1854 *Thelia bimaculata* Emm., N. Y. Agr. Rept. 5:156, pl. 3, fig. 15
1862 Uhler, Harris' Treatise, p. 221.

1869 *Thelia bimaculata* Stål, Hem. Fab. 2:115.
1869 Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1877 Glover, Rept. U. S. Dept. Agr., p. 29, fig. 17.
1878 Glover, MS. Journ. Hom., pl. 1, fig. 24.
1886 Prov., Petite Faune Can. 3:242, pl. 5, fig. 9.
1890 Smith, Ins. N. J., p. 441.
1890 Van Duzee, Psyche 5:391.
1891 Osborn, Iowa Acad. Sci. 1²:128.
1892 Godg., Ins. Life 5:93.
1894 Godg., Cat. Memb. N. A., p. 411.
1903 Buckt., Mon. Memb., p. 218, no. 9.
1908 Van Duzee, Stud. N. A. Memb., p. 57.
1909 Smith, Ins. N. J., p. 91.
1911 Matausch, Journ. N. Y. Ent. Soc. 19:195.
1912 Matausch, Bul. Amer. Mus. Nat. Hist. 31:333, pl. 29, fig. 7.
1913 Funkh., Hom. Wing Veins, figs. 1, 2, 3, 24, 25, 36.
1913 Rept. Ent. Soc. Ont. 36:135.
1915 Funkh., Ann. Ent. Soc. Amer. 8:140–151, figs. 1–10.
1915 Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 59, no. 1615.

Extremely abundant thruout basin. It inhabits only the locust and only one species of this tree (*Robinia pseudacacia*), but occurs in great numbers. The entire life history is passed on the one host (Funkhouser, 1915b). The species is easily recognized by the large size, the porrect pronotal horn, and the brilliant yellow markings of the male.

The eggs are laid on the roots, and at the base of the stem just below the surface of the forest litter. Mating begins the first week in July and continues thru the season. Egg-laying likewise is continued during the entire summer and autumn. From three to six eggs are laid in a slit. The first nymphs appear late in May and require about a month to reach maturity. The time required for development, however, is most irregular and is influenced largely by climatic and seasonal conditions. The males disappear in the fall much sooner than do the females, but both sexes may be found after the first snows. The species is largely attended by ants.

Thelia bimaculata may be found in all parts of the basin where *Robinia pseudacacia* occurs.

Technical description.— Female: Gray with indistinct darker irregular markings; porrect cylindrical horn slightly flattened and somewhat darker in color at tip; tegmina hyaline, apices fuscous, almost reaching extremity of dorsal process.

Head, including eyes, twice as broad as long, grayish yellow mottled with ferruginous and brown; margins of lorae strongly sinuate; eyes dark brown; ocelli white, nearer to each other than to the eyes and situated on a line drawn thru centers of eyes; clypeus pilose; beak extending to posterior coxae; head very sparingly punctate and sparsely pilose.

Thorax gray, deeply and densely punctate; median percurrent brown line sharpened into a ridge on extremity of horn and at apex of posterior process; sides of prothorax roughly and irregularly carinate; horn porrect and greatly variable in length, cylindrical except at extreme tip where it is flattened laterally; posterior process heavy, tectiform, gradually acute, almost straight, very slightly decurved and extending just beyond apices of tegmina.

Tegmina hyaline, apices fuscous, bases and costal regions lightly punctate; underwings hyaline, two-thirds as long as tegmina. Undersurface of body gray-brown, pubescent. Legs uniform yellow-brown; femora thick and smooth; tibiae and tarsi densely pilose.

Length 11 mm., including horn 14 mm.; width between humeral angles 5.5 mm.

Male: Differs from female in size and markings. Smaller, body somewhat less robust; porrect horn usually shorter and tending to curve; tegmina equaling apex of posterior process. Color deep chocolate brown; porrect horn almost black; apex of posterior process becoming cinnamon brown; a wide, brilliant, lemon yellow longitudinal stripe on each side of prothorax, extending from margin halfway to median dorsal line, also small patches of yellow on metopidium; head yellow with brown patches. Undersurface of abdomen darker than in female.

The genus Glossonotus Butler

The genus Glossonotus is of doubtful standing, the characters being based on the position and form of the pronotal crest, which is unfortunately much inclined to vary. Theoretically this crest is tongue-shaped, erect, and placed well forward. Of the five species that have been placed in the genus, three have been found in this basin. They may be distinguished as follows:

a. Dorsum with white median vitta . . . . *univittatus*
aa. Dorsum without vitta.
 b. Light brown with large pale markings . . . . *crataegi*
 bb. Very dark brown without markings . . . . *acuminatus*

19. *Glossonotus acuminatus* Fabricius (Plate xxvi, 7)

1781 *Membracis acuminata* Fabr., Spec. Ins. 2:317, no. 6.
1787 Fabr., Mant. Ins. 2:263, no. 12.
1788 *Cicada acuminata* Gmel., Ed. Syst. Nat. 2:2094.
1792 *Membracis acuminata* Oliv., Enc. Méth., p. 665, no. 21.
1794 Fabr., Ent. Syst. 4:11, no. 13.
1803 *Centrotus acuminata* Fabr., Syst. Rhyng., p. 18, no. 9.
1842 *Membracis acuminata* Harris, Treatise, p. 179.
1846 *Thelia acuminata* Fairm., Rev. Memb., p. 310, pl. 5, fig. 15.
1851 Walk., List Hom. B. M., p. 564.
1851 Walk., List Hom. B. M., p. 1142.
1862 *Hemiptycha acuminata* Harris, Treatise, p. 221.
1862 *Thelia acuminata* Uhler, Harris' Treatise, p. 221.
1869 *Telamona acuminatus* Stål, Hem. Fab. 2:115.
1877 *Thelia acuminata* Glover, Rept. U. S. Dept. Agr., p. 30, fig. 17.
1877 *Glossonotus acuminata* Butler, Cist. Ent. 2:222.
1878 *Thelia bimaculata* Glover, MS. Journ. Hom., pl. 1, fig. 20.
1890 *Thelia crataegi* Smith, Ins. N. J., p. 441.
1890 *Thelia acuminata* Van Duzee, Psyche 5:391.
1891 Osborn, Iowa Acad. Sci. 1^2:128.

1894 *Thelia acuminata* Godg., Cat. Memb. N. A., p. 413.
1908 *Glossonotus acuminatus* Van Duzee, Stud. N. A. Memb., p. 59.
1909 Smith, Ins. N. J., p. 91.
1911 Matausch, Journ. N. Y. Ent. Soc. 19:196.
1916 Van Duzee, Check List Hem., p. 59, no. 1617.

Very rare. Taken only in a limited area on the south side of Buttermilk Gorge, on young white oak. Attracts attention because of the very long flattened crest, almost as high as the insect is long. The life history is unknown.

Technical description.— Dark gray mottled with brown; dorsal crest high, flattened and swollen at tip; humeral angles prominent and triangular; tegmina hyaline tipped with brown, veins punctured.

Head almost as long as wide, gray with distinct scattered black punctures and fine whitish pubescence; base sinuate; eyes large, prominent, brown, extending as far as bases of humeral angles; ocelli large, prominent, pearly with white margins, nearer to each other than to the eyes; clypeus continuing inferior line of face, punctate with black, pubescent with white, tip prolonged into a point; antennae long and well developed.

Pronotum dark gray with irregular markings of brown, coarsely and regularly punctate with black, very sparingly pubescent; metopidium convex, median carina prominent and decorated with alternate lines of brown and yellowish, irregular black markings above internal angles of eyes, humeral angles prominent, triangular, flattened, acute; pronotal crest almost as high as length of pronotum, widened and flattened at tip, margin decorated with pale areas, projecting usually forward as well as upward; posterior process gradually acuminate, reaching apices of tegmina.

Tegmina hyaline, tips clouded with smoky brown, bases and margins of veins punctate, veins prominent. Undersurface of thorax fuscous; abdomen ferruginous. Legs fuscous marked with brown.

Length 10 mm.; width between tips of humeral angles, 6 mm.

20. *Glossonotus univittatus* Harris (Plate XXVI, 8)

1841 *Membracis univittata* Harris, Rept. Ins. Mass., p. 180.
1842 Harris, Treatise, p. 178, 180.
1851 *Enchenopa univittata* Walk., List Hom. B. M., p. 494.
1851 *Thelia univittata* Fitch, Cat. Ins. N. Y., p. 52.
1851 Walk., List Hom. B. M., p. 1143.
1856 Fitch, Rept. Ins. N. Y. 3:390.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:390.
1858 Fitch, Rept. Ins. N. Y. 5:804.
1858 Fitch, Trans. N. Y. Agr. Soc. 18:804.
1862 Uhler, Harris' Treatise, p. 221.
1862 *Membracis univittata* Harris, Treatise, p. 221.
1869 *Thelia univittata* Rathvon, Memb. Hist. Lanc. Co. Pa., p. 551.
1878 Uhler, List Hem. Dak. and Mont., p. 510.
1882 Lintner, First Rept. Ins. N. Y., p. 282.
1883 Saunders, Ins. Inj. Fruits, p. 289.
1886 Prov., Petite Faune Can. 3:211.
1890 Smith, Ins. N. J., p. 141.
1890 Van Duzee, Psyche 5:391.
1890 Packard, Ins. Inj. For. and Shade Trees, p. 98.
1891 Osborn, Iowa Acad. Sci. 1^2:128.

1892 *Thelia univittata* Godg., Ins. Life 5:93.
1894 Godg., Cat. Memb. N. A., p. 412.
1895 Gillette and Baker, Hem. Colo., p. 67.
1900 Lugger, Minn. Agr. Exp. Sta. Bul. 69:112.
1908 *Glossonotus univittatus* Van Duzee, Stud. N. A. Memb., p. 59.
1909 Smith, Ins. N. J., p. 91.
1911 Matausch, Journ. N. Y. Ent. Soc. 19:196.
1916 Van Duzee, Check List Hem., p. 59, no. 1619.

Rarer than the preceding species. Only one specimen reported, taken by the author on August 21, 1913, from a small hazelnut tree. Easily recognized by the white median dorsal stripe. Nothing is known of the habits or the life history of this species.

Technical description.— Resembling preceding species, but easily distinguished by white dorsal vitta down posterior median dorsal line; dorsal crest slender, inclined forward, uniform in width and not expanded at tip.

Head subquadrangular, yellowish with scattered black punctures and scanty white pubescence; base strongly sinuate; eyes prominent, deep brown, reaching bases of humeral angles; ocelli distinct, pearly, slightly protruding, nearer to each other than to the eyes; clypeus as long as wide, continuing inferior margin of face, faintly marked with longitudinal brown lines on either side, tip extending downward in a point, hirsute.

Pronotum uniform brown with pale stripe extending down dorsal line from near apex of crest to tip of posterior process; closely and deeply punctured, sparingly pubescent; posterior process heavy, broad, not reaching tips of tegmina; humeral angles prominent, triangular, blunt, not extending as far laterally as in preceding species.

Tegmina smoky hyaline, clouded with brown at tips, sparingly punctate at bases and along margins of veins. Legs and undersurface of body fuscous.

Length 9.5 mm.; width 5 mm.

21. *Glossonotus crataegi* Fitch (Plate XXVI, 9, 10)

1851 *Thelia crataegi* Fitch, Cat. Ins. N. Y., p. 52.
1851 Walk., List Hom. B. M., p. 1144.
1854 *Telamona crataegi* Emm., N. Y. Agr. Rept. 5:155, pl. 3, fig. 2.
1856 *Thelia crataegi* Fitch, Rept. Ins. N. Y. 3:334.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:334, pl. 2, fig. 5.
1869 Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1882 Lintner, First Rept. Ins. N. Y., p. 284.
1883 Saunders, Ins. Inj. Fruits, p. 46, fig. 37.
1884 Osborn, Iowa Agr. Coll., Ent. Bul. 2:90.
1890 Smith, Ins. N. J., p. 441.
1890 Van Duzee, Psyche 5:391.
1890 *Thelia pyramidoides* Smith, Ins. N. J., p. 441.
1891 *Telamona crataegi* (var.) Osborn, Iowa Acad. Sci. 1[2]:128.
1892 *Thelia crataegi* Osborn, Trans. Iowa Hort. Soc. 27:119.
1892 Godg., Ins. Life 5:93.
1893 Osborn, Fr. and For. Tree Ins., p. 24.
1893 Godg., Can. Ent. 25:196.
1894 Godg., Cat. Memb. N. A., p. 412.
1894 Bruner, Rept. Nebr. Hort. Soc. 25:162.
1900 Lugger, Minn. Agr. Exp. Sta. Bul. 69:111–112.
1908 *Glossonotus crataegi* Van Duzee, Stud. N. A. Memb., p. 59.

1909 *Glossonotus crataegi* Smith, Ins. N. J., p. 91.
1913 Funkh., Hom. Wing Veins, figs. 37, 61.
1915 Funkh., Fitch's Types, p. 50.
1916 Van Duzee, Check List Hem., p. 59, no. 1621.

Rare. Has been taken only occasionally on quince, crab apple, and hawthorn in more or less cultivated areas. May have been introduced on nursery stock from the northern part of the State, where it is fairly common. The mottled colors on the pronotum prevent its being mistaken for any other species of the genus.

H. H. Knight has found the species commonly on quince in the vicinity of Batavia, New York, during the month of July, and has succeeded in obtaining some excellent photographs of the insects, of which Plate XL, 1, and Plate XLI, in this study (pages 369 and 395) are examples. The nymphs, however, were not seen.

Technical description.— A strikingly marked species, not to be confused with either of the two preceding; smaller, shorter, and stouter than either *G. acuminatus* or *G. univittatus*; pronotum brilliantly decorated with areas of chestnut red, pale whitish yellow, and deep brown; crest erect, broad, flattened, dark in color, very variable in length.

Head greenish gray punctured with black, irregularly sculptured, not pubescent; eyes prominent, brown, reaching bases of humeral angles; ocelli not prominent, pearly, much nearer to each other than to the eyes; clypeus longer than wide, projecting below inferior line of face, tip hirsute.

Pronotum coarsely punctate, sparingly pubescent, faintly longitudinally rugose on posterior process; humeral angles triangular, short, blunt; dorsal crest variable in height, broad, flattened, generally uniformly ridged, margin compressed; posterior process short, heavy, blunt, not reaching apices of tegmina.

Coloration: pale greenish yellow mottled with brown on front of metopidium, this color extending in a band over humeral angles and ending in a broad pale patch at lateral margin; humeral angles chestnut; dorsal crest deep brown mottled with chestnut on sides, chestnut on posterior line, this chestnut band extending down each side of pronotum to lateral margin and bordered with dark brown; pale transverse band across base of posterior process; posterior process brown.

Tegmina hyaline, tips clouded with brown, veins broad and prominent, bases and margins of veins punctate. Undersurface of body ferruginous and pubescent. Legs very hairy; tarsi ferruginous.

Length 8 mm.; width 4.5 mm.

The genus Heliria Stål

Heliria is another genus of rather doubtful standing, the characters, like those of Glossonotus, depending on the shape of the pronotal crest, which is supposedly step-shaped. Only one species occurs in the basin.

22. *Heliria scalaris* Fairmaire (Plate XXVI, 11, 12)

1846 *Thelia scalaris* Fairm., Rev. Memb., p. 311, no. 18, pl. 5, fig. 14.
1851 *Telamona fagi* Fitch, Cat. Ins. N. Y., p. 51.

1851 *Thelia scalaris* Walk., List Hom. B. M., p. 565.
1851 *Telamona fagi* Walk., List Hom. B. M., p. 1146.
1854 Emm., N. Y. Agr. Rept. 5:154, pl. 3, fig. 10.
1867 *Heliria scalaris* Stål, Bid. Memb. Syst., p. 556.
1869 Stål, Bid. Memb. Kän., p. 249.
1877 *Telamona scalaris* Butler, Cist. Ent. 2:222.
1886 Prov., Petite Faune Can. 3:243.
1889 *Telamona fagi* Van Duzee, Can. Ent. 21:6.
1890 *Heliria scalaris* Van Duzee, Psyche 5:390.
1890 *Telamona fagi* Smith, Ins. N. J., p. 422.
1891 Osborn, Iowa Acad. Sci. 1²:128.
1892 *Heliria scalaris* Godg., Ent. News 3:200.
1892 Godg., Ins. Life 5:93.
1894 Godg., Cat. Memb. N. A., p. 423.
1895 Gillette and Baker, Hem. Colo., p. 67.
1903 Buckt., Mon. Memb., p. 218, no. 8.
1908 Van Duzee, Stud. N. A. Memb., p. 61.
1909 Smith, Ins. N. J., p. 91.
1913 Funkh., Hom. Wing Veins, figs. 41, 64.
1915 Funkh., Fitch's Types, p. 50.
1916 Van Duzee, Check List Hem., p. 59, no. 1623.

Rare. Taken on west side of lake in the higher wooded parts of the hills by beating small bushes and shrubs. The particular host is not known, and nothing is known of the life history of the species.

Technical description.— A small species, uniform brown in color; crest as high as its length at base; posterior process not reaching apices of tegmina; tegmina smoky hyaline, tips brown.

Head as wide as long, sculptured, yellowish, irregularly punctate with brown, sparingly pubescent; base strongly sinuate; eyes prominent, brown, reaching bases of humeral angles; ocelli prominent, translucent, nearer to each other than to the eyes; clypeus extending below inferior margin of face, yellowish, punctured with brown, pubescent.

Pronotum uniform brown, coarsely punctured; dorsal crest swollen at base, flattened at apex, as high as its length at base, distinctly step-shaped, anterior lobe rounded and projecting forward, posterior lobe sharply angular, two-thirds as high as anterior, both lobes in some cases margined with patches of darker brown; posterior process short, heavy, acute, not reaching apices of tegmina; humeral angles triangular, flattened, blunt.

Tegmina smoky hyaline, bases dark brown and punctate, tips brown, veins heavy and often punctured along margins. Undersurface of thorax ferruginous, segments margined with paler; abdomen brown. Legs ferruginous; tibiae and tarsi hairy.

Length 8 mm.; width 4.8 mm.

The genus Telamona Fitch

The genus Telamona is a typical New York genus, erected by Fitch (1851) from forms from this State and containing a large number of species. The genus is in great need of revision, practically all the species having been described from pronotal characters which have since been found to vary to such an extent as to make the validity of some species very doubtful. From a large amount of material it has been possible to recognize fifteen species, but a large series of specimens collected in the basin remain

unidentified. The genus is primarily tree-inhabiting and is common on oak and basswood, and the insects are solitary in habit. The adults are strong flyers and are difficult to capture. Only a few have been reared, due to the difficulty of keeping the host plants in the insectary. It is believed that the species recognized may be separated by the following key, which, however, is admittedly weak in that it has been necessary to make use of the pronotal characters on which the species were founded:

a. Crest obsolete or only faintly indicated . . . . *obsoleta*
aa. Crest prominent.
  b. Crest leaning forward over head . . . . *projecta*
  bb. Crest vertical or nearly so.
    c. Crest slender; pointed at tip.
      d. Crest highest in front . . . . *declivata*
      dd. Crest highest in middle.
        e. Crest as broad as high . . . . *barbata*
        ee. Crest twice as high as broad . . . . *pyramidata*
    cc. Crest broad; rounded or truncate at tip.
      d. Front margin of crest perpendicular or nearly so.
        e. Females bright green; males yellow, banded with brown . . . . *unicolor*
        ee. Neither sex green.
          f. Posterior margin of crest white . . . . *monticola*
          ff. Posterior margin of crest not white.
            g. Concolorous ferruginous . . . . *pruinosa*
            gg. Mottled or banded.
              h. Yellow mottled with brown . . . . *tristis*
              hh. Gray with transverse brown band . . . . *ampelopsidis*
      dd. Front margin of crest sloping.
        e. Crest as high as or higher than broad.
          f. Posterior margin white . . . . *querci*
          ff. Tip hollowed out posteriorly . . . . *concava*
        ee. Crest not so high as broad.
          f. Pale yellow marked with light brown . . . . *Westcotti*
          ff. Brown banded with darker . . . . *reclivata*
          fff. Gray with oblique brown fascia . . . . *decorata*

23. *Telamona declivata* Van Duzee (Plate XXVI, 13)

1908 *Telamona declivata* Van Duzee, Stud. N. A. Memb., p. 64.
1909 Smith, Ins. N. J., p. 91.
1914 Van Duzee, Trans. S. Diego Soc. Nat. Hist 2^1:50.
1916 Van Duzee, Check List Hem., p. 59, no. 1628.

Very rare. One record for the basin, taken on July 12, 1899. No record of host. Easily recognized by the very peculiar shape of the crest, which is much higher in its anterior than in its posterior half, making a distinct step as in the genus Heliria.

Technical description.— Long, narrow pronotum; crest high, sloping steeply backward and more or less step-shaped suggesting the genus Heliria; posterior process exceeding tips of tegmina; tegmina smoky hyaline, punctate at bases and clouded with brown at tips.

Head broader than long, ruggedly sculptured, yellowish with large punctures and splashes of brown, sparingly pubescent; base regularly sinuate; eyes large, very prominent, brown; ocelli small, pearly, not prominent, nearer to each other than to the eyes; inferior margin of vertex deeply sinuate; clypeus subtriangular, coarsely punctate with brown, tip extended below line of face, hirsute.

Pronotum ferruginous brown mottled with darker, densely and coarsely punctate thruout, not pubescent; humeral angles prominent, triangular, flattened, blunt; dorsal crest as high as its width at base, sloping backward, tip and posterior margin compressed, posterior margin step-shaped; transverse brown fascia extending from posterior margin of crest to lateral margin of pronotum; posterior process long, slender, acuminate, extending beyond tegmina.

Tegmina smoky hyaline, basal third punctate, veins prominent, apex clouded with brown. Undersurface of thorax fuscous; abdomen brown. Legs ferruginous mottled with brown; tibiae hairy.

Length 10 mm.; width between humeral angles, 6 mm.

24. *Telamona pyramidata* Uhler (Plate xxvi, 14)

1877 *Telamona pyramidata* Uhler, Wheeler's Rept. App. J., no. 1333.
1890 Van Duzee, Psyche 5:391.
1894 Godg., Cat. Memb. N. A., p. 422.
1895 Gillette and Baker, Hem. Colo., p. 67.
1908 Van Duzee, Stud. N. A. Memb., p. 64.
1913 Branch, Kans. Univ. Sci. Bul. 8:104, figs. 30, 31, 84.
1916 Van Duzee, Check List Hem., p. 59, no. 1629.

Rare. Occasionally taken on chestnut oak (*Quercus Prinus*). A medium-sized, mottled brownish species with a stripe of lighter shade along the median dorsal line. The crest is high and gradually acuminate. The habits and life history are unknown.

Technical description.— Long, narrow body; crest triangular and pyramidal, as the name would suggest; mottled brown with a dark transverse fascia extending from tip of crest to lateral margin of pronotum, and a second shorter fascia behind it; posterior process exceeding tips of tegmina; tegmina hyaline, punctate at bases, brown at apices. Differs from preceding species chiefly in shape of dorsal crest.

Head wider than long, yellowish with large irregular punctures of brown, sparingly pubescent; base regularly sinuate; eyes large, prominent, gray; ocelli large, prominent, somewhat protruding, translucent; clypeus subtriangular, sutures distinct, apex slightly produced, hairy.

Pronotum deeply punctate, not pubescent; metopidium convex, decorated with patches of yellowish and dark brown, median carina prominent, heavy, black broken by circular areas of yellowish; humeral angles prominent, tectiform, blunt, brownish; dorsal crest triangular, rounded at tip, margin flattened and brown, posterior margin pale; posterior process long, slender, slightly curving downward, extending beyond tips of tegmina; median carina percurrent.

Tegmina hyaline, bases and costal margins coarsely punctate but not pubescent, tips brown. Undersurface of thorax flavous; abdomen dark brown. Legs yellowish; tibiae mottled with brown, hairy; tarsi flavous; claws ferruginous.

Length 9–11 mm.; width 5–6 mm.

25. *Telamona barbata* Van Duzee (Plate xxvi, 15)

1908 *Telamona barbata* Van Duzee, Stud. N. A. Memb., p. 65.
1912 Matausch, Bul. Amer. Mus. Nat. Hist. 31:333, pl. 29, fig. 9.
1916 Van Duzee, Check List Hem., p. 59, no. 1630.

Rare. A small brownish species with a weak pyramidal crest. The crest is darker than the remainder of the pronotum. The species has been taken on white oak and on basswood. Nothing is known of its habits or of its life history. Commoner in higher parts of the basin than elsewhere, in regions where older trees abound.

Technical description.— Small; mottled greenish brown; crest low and rounded; posterior process not reaching tips of tegmina; tegmina smoky hyaline, tips broadly clouded.

Head much wider than long, greenish, finely punctate, sparingly pubescent, sutures well marked; base regularly sinuate; eyes very prominent, protruding, brownish; ocelli small, pearly, distinct, slightly protruding, much nearer to each other than to the eyes; clypeus small, sinuately rounded above, tip extending only slightly below inferior margin of face.

Pronotum very irregularly punctate, some punctures coarse and deep, others fine and shallow, sparingly pubescent; metopidium low, greenish, median carina very prominent and brown, yellowish depression above each eye; humeral angles not prominent, rounded; dorsal crest low, not so high as its width at base, darker in color than remainder of pronotum, posterior margin pale; posterior process short, hairy, longitudinally striate, sharp at tip, not reaching apices of tegmina.

Tegmina hyaline, veins very prominent, bases weakly punctate, apices broadly clouded with brown. Legs and undersurface of body concolorous fuscous; abdomen brown; tibiae spined with minute hairs.

Length to tips of tegmina, 8 mm.; width 3.5 mm.

26. *Telamona obsoleta* Ball (Plate XXVI, 16)

1903 *Telamona obsoleta* Ball, Proc. Biol. Soc. Wash. 16:178, pl. 1, figs. 2, 2a.
1908 Van Duzee, Stud. N. A. Memb., p. 66
1916 Van Duzee, Check List Hem., p. 59, no. 1632.

Rare. A rather large, heavy-bodied species, with the crest very much reduced. Has been found only on the highest parts of the hills, on various species of oak. The nymphs of the species have never been recognized, and nothing is known of the habits or of the life history. Only a few specimens have been taken locally.

Technical description.— Short, thick, heavy body; crest reduced to a rounded lobe; posterior process not reaching apex of abdomen; tegmina smoky hyaline tipped with brown.

Head wider than long, yellowish with black punctures and scattered white pubescence, center of each vertex depressed and broadly black; base regularly sinuate; eyes prominent, brown; ocelli prominent, somewhat protruded, margins white, nearer to each other than to the eyes; clypeus subtriangular, depressed at base, sutures distinct, hirsute.

Pronotum closely punctate, sparingly pubescent, greenish brown mottled with ferruginous; metopidium only slightly convex, smooth depression above each eye, median carina prominent, black interrupted with pale; humeral angles not prominent, triangular, rounded at tips; dorsal crest low, rounded, gradually sloping before, steeper behind, margins slightly flattened; posterior process short, heavy, blunt, tectiform, longitudinally striate, not reaching apex of abdomen and extending only about one-third the distance between the internal angles and the tips of the tegmina.

Tegmina smoky hyaline, bases punctate, tips clouded with brown, veins heavy, inclined to punctuation. Undersurface of thorax fuscous, abdomen brown. Legs mottled with green and brown; tibiae hairy; tarsi ferruginous.

Length 9 mm.; width 4 mm.

27. *Telamona Westcotti* Goding (Plate XXVI, 17)

1894	*Telamona Westcotti*	Godg., Cat. Memb. N. A., p. 415.
1908		Van Duzee, Stud. N. A. Memb., p. 66.
1915		Metcalf, Hom. No. Car., p. 7.
1916		Van Duzee, Check List Hem., p. 59, no. 1633.

Very rare. A fine large species, with long, sloping pronotum strikingly marked with pale yellow or gray and light brown. The crest is low and broad, with the tip squarely truncate. There is no record of the host and nothing is known of the life history of the species.

Technical description.— Fine, large, strikingly marked species; long, narrow pronotum, decorated with yellow, gray, and brown; posterior process not reaching apices of tegmina; tegmina hyaline tipped with brown.

Head nearly as long as broad, sculptured, yellowish, irregularly punctate with brown especially around margins; base sinuate; eyes large, brown; ocelli not prominent, transparent, slightly protruding, nearer to each other than to the eyes; clypeus slightly convex, faintly punctate, tip rounded, hirsute.

Pronotum finely punctate, sparingly pubescent; ground color yellowish or gray, with brown fascia over metopidium, at base of crest extending to lateral margin, and at apex; humeral angles prominent, flat, triangular, tips blunt; dorsal crest longer than high, front margin slightly sloping, posterior margin nearly vertical, tip squarely truncate, area behind crest pale; lateral areas of pronotum and posterior process roughly longitudinally striate; posterior process long, suddenly acute at apex, not reaching tips of tegmina.

Tegmina hyaline, somewhat wrinkled, bases punctate, tips clouded with brown. Undersurface of thorax fuscous; abdominal segments margined with brown. Legs mottled; tibiae hairy.

Length 10.5 mm.; width 5 mm.

28. *Telamona reclivata* Fitch (Plate XXVII, 1, 2)

1851	*Telamona reclivata*	Fitch, Cat. Ins. N. Y., p. 51.
1851		Walk., List Hom. B. M., p. 1145.
1854		Emm., N. Y. Agr. Rept. 5:155, pl. 3, fig. 7.
1886		Prov., Petite Faune Can. 3:241.
1889		Van Duzee, Can. Ent. 21:6.
1890		Van Duzee, Psyche 5:391.
1890		Smith, Ins. N. J., p. 442.
1891		Osborn, Iowa Acad. Sci. 1²:128.
1892		Godg., Ins. Life 5:93.
1894		Godg., Cat. Memb. N. A., p. 414.
1895		Gillette and Baker, Hem. Colo., p. 67.
1905		Van Duzee, N. Y. St. Mus. Bul. 97:552.
1907		Baker, Can. Ent. 39:115.
1908		Van Duzee, Stud. N. A. Memb., p. 67.
1909		Smith, Ins. N. J., p. 92.
1915		Funkh., Fitch's Types, p. 50.
1916		Van Duzee, Check List Hem., p. 60, no. 1635.

Very common on basswood. Abundant thruout the basin. A difficult species to delimit owing to the variation in shape of the pronotal crest. May be generally recognized by the large size, rounded sloping crest,

PLATE XXVII

1, Pronotum of *Telamona reclivata* Fitch; 2, last nymphal instar

3, Pronotum of *Telamona monticola* Fabricius

4, Pronotum of *Telamona ampelopsidis* Harris; 5, frontal outline; 15, lateral outline of last nymphal instar

6, Pronotum of *Telamona tristis* Fitch

7, Pronotum of *Telamona concava* Fitch

8, Pronotum of *Telamona projecta* Butler

9, Pronotum of *Telamona unicolor* Fitch; 10, last nymphal instar

11, *Telamona decorata* Ball; 12, head

13, Pronotum of *Archasia Belfragei* Stål

14, Pronotum of *Smilia camelus* Fabricius

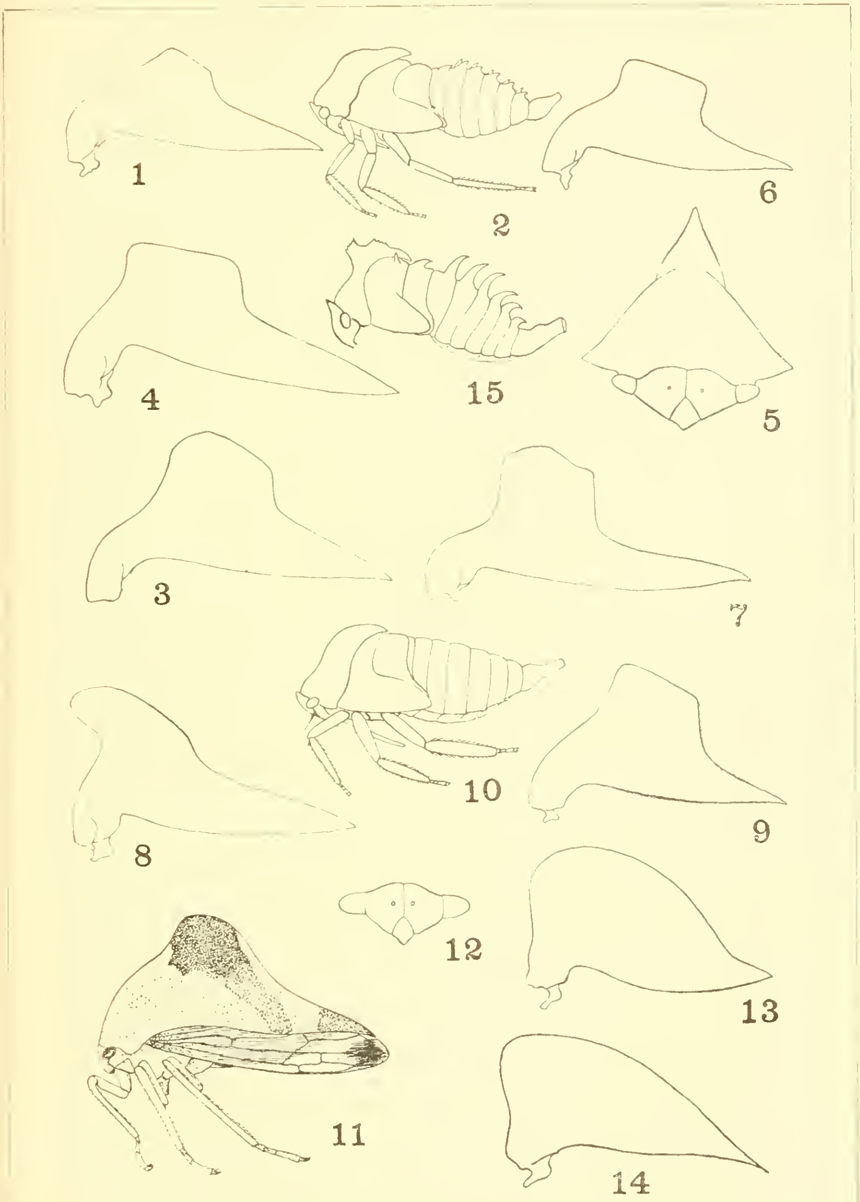


PLATE XXVII

long posterior process, and markings of dark brown. The nymphs are found on the same hosts as the adults, and all stages may be collected during July and August.

Because of the fact that most of the species of the genus Telamona inhabit oak, it has been impossible in the course of this study to positively identify the eggs without rearing the species in each case, and this has not been accomplished except in a few instances. The nymphs do not live when confined under netting on the tree, and do not survive transportation and transfer to new hosts in the laboratory; and it will require very patient work for a number of years to work out the life histories for all of the Telamonas.

In the few cases in which nymphs have been successfully reared to maturity a wide variation has been found in the individuals of a single egg mass, suggesting that the species here recognized may not all stand after careful biologic data have been obtained.

It has been suggested that a careful revision of the genus is needed, and such a revision should be based largely on a study of life histories.

Technical description.— Varies greatly in shape and size of dorsal crest and in coloration; crest usually higher before than behind, marked with a brown fascia which extends to the lateral margin; metopidium hairy; tegmina tipped with brown.

Head broader than long, greenish marked with reddish patches, sculptured, sparingly punctate, pubescent with short black hairs; base high and sinuate; eyes prominent, brown; ocelli large, protruding, nearer to each other than to the eyes; clypeus nearly flat, greenish, smooth, pubescent, sutures distinct, tip extending far below inferior margin of face.

Pronotum finely punctate and pubescent; metopidium convex, median carina prominent; dorsal crest sloping, longer than high, tip truncate, posterior margin pale; posterior process gradually acute, not reaching tips of tegmina.

Tegmina hyaline, wrinkled, bases deeply punctate with black, tips marked with deep brown triangular fascia. Undersurface of thorax flavous and pubescent; abdomen brown, segments margined with paler. Legs yellowish; tibiae hairy.

Length 9 mm.; width 4.5 mm.

29. *Telamona monticola* Fabricius (Plate XXVII, 3)

1803	*Membraeis monticola*	Fabr., Syst. Rhyng., p. 7, no. 4.
1869	*Telamona monticola*	Stål, Hem. Fab. 2:115.
1877		Butler, Cist. Ent. 2:221, no. 5.
1878		Glover, MS. Journ. Hom., pl. 1, fig. 18.
1884		Uhler, Stand. Nat. Hist., p. 225.
1890		Van Duzee, Psyche 5:391.
1891		Osborn, Iowa Acad. Sci. 1²:128.
1893		Godg., Can. Ent. 25:171.
1894		Godg., Cat. Memb. N. A., p. 416.
1895		Gillette and Baker, Hem. Colo., p. 67.
1900		Lugger. Minn. Agr. Exp. Sta. Bul. 69:112.
1901		Howard, Ins. Book, p. 238.

1903 *Telamona monticola* Buckt., Mon. Memb., p. 218.
1903 *Telamona brunneipennis* Buckt., Mon. Memb., p. 197, pl. 43, figs. 1, 1a.
1908 Van Duzee, Stud. N. A. Memb., p. 68.
1908 *Telamona monticola* Van Duzee, Stud. N. A. Memb., p. 67.
1909 Van Duzee, Flor. Hem., p. 206.
1909 Smith, Ins. N. J., p. 92.
1915 Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 60, no. 1645.

This species is included only tentatively, as its presence in the basin is doubtful. A long series of specimens in the Cornell University collection have been determined as *T. monticola* by E. P. Van Duzee, but these do not show the straight frontal outline of the crest as figured by Fairmaire, and recent collecting has brought to light many forms that gradate between these and typical specimens of *T. querci*. It is probable that this species has been confused with the species *T. querci* as described later.

Technical description.— Large, robust species; concolorous brown spotted with greenish; dorsal crest high, rounded, greenish posteriorly; posterior process not reaching tips of tegmina; tegmina punctate at base, brown at tips.

Head one-fourth broader than long, sculptured, yellowish punctured with brown above, black below, vertex pubescent at lower angles of eyes; eyes prominent, dark brown; ocelli large, greenish, nearer to each other than to the eyes; clypeus with median longitudinal depression, punctate with black, tip extending far below inferior margin of face, hairy.

Pronotum finely punctate, sparingly pubescent, concolorous light brown spotted with green; metopidium convex, median carina prominent, black, interrupted with greenish spots; humeral angles not prominent, rounded; dorsal crest about as high as long, rounded at tip; posterior process rather short, acute, not reaching tips of tegmina.

Tegmina hyaline, wrinkled, bases coarsely but sparingly punctate with black, tips deep brown. Undersurface of thorax, abdomen, and legs flavous; tibiae mottled and hairy; tarsi ferruginous, claws fuscous.

Length 11 mm.; width 6 mm

30. *Telamona querci* Fitch

1851 *Telamona querci* Fitch, Cat. Ins. N. Y., p. 51.
1851 *Telamona quercus* Walk., List Hom. B. M., p. 1145.
1854 *Telamona querci* Emm., N. Y. Agr. Rept. 5: pl. 3, fig. 4.
1876 Uhler, List Hem. West Miss. River, p. 344.
1877 *Telamona quercus* Butler, Cist. Ent. 2:222, no. 10.
1890 *Thelia quercus* Smith, Ins. N. J., p. 441.
1890 *Telamona querci* Smith, Ins. N. J., p. 442.
1892 *Telamona monticola* [=*querci*] Godg., Ins. Life 5:92.
1893 *Telamona querci* Godg., Can. Ent. 25:171.
1895 Gillette and Baker, Hem. Colo., p. 67.
1903 Buckt., Mon. Memb., p. 218.
1908 Van Duzee, Stud. N. A. Memb., p. 67, pl. 2, fig. 7.
1913 Shelford, Anim. Comm., p. 234, fig. 212; p. 259, table 59.
1915 Weiss, Ent. News 26:102.
1915 Funkh., Fitch's Types, p. 50.
1916 Van Duzee, Check List Hem., p. 60, no. 1644.

Abundant thruout the basin on oak. Particularly common on small white and chestnut oaks on the hillsides. Solitary in habit and quick in movement. The nymphs seek the outer branches and the axils of the leaves, while the adults prefer the twigs of second-year growth.

The species may be recognized by the white vitta along the posterior median line of the dorsal crest. This is a stout, robust species, common thruout the summer.

Technical description.— Very close to preceding species; pronotum shorter, darker; dorsal crest with prominent pale fascia on posterior margin; tegmina nearly hyaline, tips faintly clouded.

Head roughly sculptured, flavous mottled with brown, faintly longitudinally striate, very faintly punctate, pubescent; base weakly sinuate; eyes prominent, dark brown; ocelli very prominent, protruding, brownish, margins pale, much nearer to each other than to the eyes; clypeus nearly flat, punctate, pubescent, base marked with brown, tip extended below inferior margin of face.

Pronotum densely but finely punctate, sparingly pubescent, dark brown mottled with green; metopidium convex, median carina prominent, black interrupted with pale green; humeral angles short and blunt; dorsal crest sloping backward, longer than high, higher before than behind, posterior margin distinctly pale; posterior process short, acute, marked with greenish before apex, not reaching tips of tegmina.

Tegmina hyaline, bases punctured but not pubescent, tips clouded with brown, veins brown. Undersurface of body brown. Legs flavous; tibiae hairy.

Length of pronotum 9 mm., to tips of tegmina 11 mm.; width 5.5 mm.

31. *Telamona ampelopsidis* Harris (Plate XXVII, 4, 5, 15)

1833 *Membracis cissi* Harris, List Ins. Mass., p. 584.
1841 *Membracis ampelopsidis* Harris, Rept. Ins. Mass., p. 180.
1842 Harris, Treatise, p. 178.
1846 *Thelia cyrtops* Fairm., Rev. Memb., p. 310, no. 17, pl. 5, fig. 13.
1851 Walk., List Hom. B. M., p. 565.
1851 *Telamona ampelopsidis* Fitch, Cat. Ins. N. Y., p. 51.
1851 Walk., List Hom. B. M., p. 1145.
1854 Emm., N. Y. Agr. Rept. 5:154, pl. 3, fig. 9
1862 *Membracis ampelopsidis* Harris, Treatise, p. 220.
1862 *Telamona ampelopsidis* Uhler, Harris' Treatise, p. 178.
1869 *Membracis ampelopsidis* Harris, Ent. Corresp., p. 334.
1870 Riley, Amer. Ent. and Bot. 2:245.
1877 *Telamona ampelopsidis* Glover, Rept. U. S. Dept. Agr., p. 29, fig. 12.
1877 Butler, Cist. Ent. 2:221, no. 7.
1877 *Telamona cyrtops* Butler, Cist. Ent. 2:222, no. 11.
1878 *Telamona ampelopsidis* Glover, MS. Journ. Hom., pl. 2, fig. 25.
1886 Prov., Petite Faune Can. 3:243.
1890 Van Duzee, Psyche 5:391.
1890 Smith, Ins. N. J., p. 442.
1891 Osborn, Iowa Acad. Sci. 1^2:128.
1894 Godg., Cat. Memb. N. A., p. 116.
1903 *Thelia cyrtops* Buckt., Mon. Memb., p. 218.
1908 Van Duzee, Stud. N. A. Memb., p. 68.
1908 *Telamona ampelopsidis* Van Duzee, Stud. N. A. Memb., p. 68.

1909	*Telamona ampelopsidis*	Smith, Ins. N. J., p. 92.
1910		Matausch, Journ. N. Y. Ent. Soc. 18:169.
1913		Funkh., Hom. Wing Veins, p. 82, figs. 4, 11, 19, 38.
1915		Metcalf, Hom. No. Car., p. 7.
1916		Van Duzee, Check List Hem., p. 60, no. 1646.

A large, robust, well-marked species. Very abundant in all parts of the basin on Virginia creeper (*Psedera quinquefolia* L., formerly placed in the genus Ampelopsis, from which the specific name of the insect was derived). This is the commonest species of Telamona in the region. Since it has never been taken on any other host and no other species of the genus inhabits Virginia creeper, this species may be fairly surely identified by its habitat. The markings are distinct and characteristic. The males are in some cases solid black in color — a feature formerly thought to mark the older specimens, but this has been found not to be the case — and are much smaller than the females.

Large numbers of these insects have been taken on the hills west of the lake between Trumansburg and Interlaken, and around the buildings of the farms of this region. They are also plentiful on the vines covering the boathouses at the foot of Cascadilla Creek.

The eggs are laid in the axils of the leaves and are deeply embedded in the stems. Two or three egg deposits are made by one female at one time, each oviposition requiring about twenty minutes with a rest of about ten minutes between. The eggs winter over and hatch early in June. About five weeks is required for the nymphs to reach maturity. Mating begins about the middle of July and oviposition almost immediately afterward. The entire life history has been followed on the one host, and apparently the nymphs need no other food.

Technical description.— Fine, large, well-marked species; crest high, erect, front margin nearly perpendicular, hind margin sloping; ground color grayish with brown transverse fascia across metopidium, deep brown area at frontal base, brown fascia extending from posterior tip of crest to lateral margin of pronotum; tegmina hyaline, with brown tips.

Head yellowish faintly marked with brown below, sculptured, finely punctate, sparingly pubescent; eyes prominent, grayish brown; ocelli large, yellowish, nearer to each other than to the eyes; clypeus smooth, pubescent, tip triangular.

Pronotum finely punctate, very sparingly pubescent; metopidium yellow at frontal margin, black spot above each eye, median carina prominent, black; humeral angles prominent, blunt, extending beyond the eyes as far as the length of the eyes; dorsal crest higher before than behind, margin somewhat flattened; posterior process long, strong, heavy, extending almost to tips of tegmina.

Tegmina hyaline, lightly punctate at base and along costal margins, tips brown. Undersurface of body generally uniform gray-brown.

Male smaller and darker than female, often without characteristic markings.

Length, female 10 mm., male 8–9 mm.; width, female 6 mm., male 5 mm.

32. *Telamona tristis* Fitch (Plate xxvii, 6)

1851 *Telamona tristis* Fitch, Cat. Ins. N. Y., p. 51.
1851 *Telamona coryli* Fitch, Cat. Ins. N. Y., p. 51.
1851 Walk., List Hom. B. M., p. 1145.
1851 *Telamona tristis* Walk., List Hom. B. M., p. 1145.
1854 *Telamona coryli* Emm., N. Y. Agr. Rept. 5:155, pl. 3, fig. 6
1856 Fitch, Rept. Ins. N. Y. 3:473.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:473.
1856 *Telamona tristis* Fitch, Rept. Ins. N. Y. 3:474.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:474.
1869 Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1869 *Telamona coryli* Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1877 Butler, Cist. Ent. 2:221, no. 6.
1877 *Telamona tristis* Butler, Cist. Ent. 2:221, no. 9.
1886 Prov., Petite Faune Can. 3:243.
1889 Van Duzee, Can. Ent. 21:6.
1889 *Telamona coryli* Van Duzee, Can. Ent. 21:6.
1890 Van Duzee, Psyche 5:391.
1890 Smith, Ins. N. J., p. 442.
1890 *Telamona tristis* Smith, Ins. N. J., p. 442.
1891 *Telamona coryli* (?) Osborn, Iowa Acad. Sci. 1^2:128.
1892 *Telamona coryli* et *tristis* Godg., Ins. Life 5:93.
1893 *Telamona coryli* Godg., Can. Ent. 25:172.
1893 *Telamona tristis* Godg., Can. Ent. 25:172.
1894 *Telamona coryli* Godg., Cat. Memb. N. A., p. 419.
1894 *Telamona spreta* Godg., Cat. Memb. N. A., p. 417.
1896 *Telamona tristis* Fowler, B. C. A., p. 144.
1896 Fowler, B. C. A., p. 145.
1903 Buckt., Mon. Memb., p. 198.
1908 *Telamona coryli* Van Duzee, Can. Ent. 40:115.
1908 *Telamona spreta* Van Duzee, Stud. N. A. Memb., p. 69.
1908 *Telamona tristis* Van Duzee, Stud. N. A. Memb., p. 69.
1908 Van Duzee, Can. Ent. 40:115.
1908 *Telamona coryli* Van Duzee, Stud. N. A. Memb., p. 68.
1909 Smith, Ins. N. J., p. 92.
1909 *Telamona tristis* Van Duzee, Can. Ent. 41:383.
1915 Funkh., Fitch's Types, p. 50.
1916 Van Duzee, Check List Hem., p. 60, no. 1647.

Rare. Occasionally taken on hazelnut and less commonly on oak. Very conspicuous because of its light mottled colors. Habits and life history unknown.

Technical description.— Near preceding species in appearance, but smaller and lighter and differing in coloration; crest high and square, higher before than behind; tegmina hyaline tipped with brown; protonum yellow mottled with red-brown.

Head subquadrate, yellowish, faintly longitudinally striate, finely punctuate, closely pubescent, faintly mottled with brown; eyes prominent, brown; ocelli pearly, nearer to each other than to the eyes; clypeus pubescent, tip slightly extending below inferior margin of face.

Pronotum densely punctate, not pubescent, ground color light yellow, a broad transverse reddish brown fascia nearly covering metopidium, a second on front of crest, and a third extending down posterior third of crest and reaching lateral margin of pronotum; humeral

angles produced, triangular, flattened, blunt, tips dark; dorsal crest nearly square, truncate at tip, posterior margin pale; posterior process long, sharp, not quite reaching tips of tegmina.
Tegmina smoky hyaline, bases opaque and punctate, tips brown. Undersurface of thorax flavous; abdomen brown. Legs ferruginous.
Length 8.5 mm.; width 5 mm.

33. *Telamona concava* Fitch (Plate xxvii, 7)

1851 *Telamona concava* Fitch, Cat. Ins. N. Y., p. 50.
1851 Walk., List Hom. B. M., p. 1146.
1854 *Telamona ornata* Emm., N. Y. Agr. Rept. 5:155, pl. 3, fig. 8.
1877 *Telamona concava* Butler, Cist. Ent. 2:221, no. 8.
1890 Van Duzee, Psyche 5:391.
1890 Smith, Ins. N. J., p. 442.
1893 Godg., Can. Ent. 25:172.
1894 Godg., Cat. Memb. N. A., p. 419.
1908 Van Duzee, Stud. N. A. Memb., p. 69.
1908 *Telamona ornata* Van Duzee, Stud. N. A. Memb., p. 69.
1909 Smith, Ins. N. J., p. 92.
1909 *Telamona concava* Van Duzee, Can. Ent. 41:383.
1915 Funkh., Fitch's Types, p. 50.
1916 Van Duzee, Check List Hem., p. 60, no. 1648.

Very rare. Only two records for the basin, both from Ithaca; one specimen taken by D. F. Atkinson on June 30, 1885, and the other taken on August 30, 1890, collector not recorded. Both specimens are in the Cornell University collection.

Distinct because of the peculiar step-like notch in the dorsal crest Hosts and habits unknown.

Technical description.— Large, well-marked species, with distinct notch on upper posterior angle of high crest; yellowish with distinct brown markings; posterior process not reaching tips of tegmina; tegmina hyaline with brown tips.

Head nearly as long as broad, punctate, pubescent, sculptured, greenish yellow with brown markings, brown protuberance near internal upper angle of each vertex; base strongly sinuate; eyes large, gray-brown; ocelli small, prominent, orange, slightly protruding, nearer to each other than to the eyes; clypeus triangular, continuing inferior outline of face, tip narrow, somewhat projecting, hairy.

Pronotum coarsely punctate, not pubescent, greenish yellow marked with patches of brown, crest entirely brown, brown fascia from posterior base of crest to lateral margins of pronotum, extremity of posterior process brown; metopidium convex, median carina prominent; humeral angles prominent, triangular, flat, black line near anterior margin, tips blunt; dorsal crest high, quadrate, distinctly sinuate or notched at upper posterior angle, posterior margin nearly perpendicular; posterior process long, straight, pointed, almost reaching tips of tegmina.

Tegmina hyaline, veins prominent, bases somewhat punctate, tips clouded with brown. Undersurface of body flavous. Legs yellow; tibiae mottled with brown.

Length 10 mm.; width 5.5 mm.

34. *Telamona projecta* Butler (Plate xxvii, 8)

1877 *Telamona projecta* Butler, Cist. Ent. 2:221, pl. 3, fig. 12.
1908 *Telamona cucullata* Van Duzee, Stud. N. A. Memb., p. 70, pl. 2, fig. 10.

1908 *Telamona projecta* Van Duzee, Stud. N. A. Memb., p. 120.
1916 *Heliria projecta* Van Duzee, Check List Hem., p. 59, no. 1624.

Rare. No specimens have been taken in the basin since 1893 and there is no record of host or habits.

The overhanging crest is very characteristic and the species will be easily recognized if again found.

Technical description.— Very distinct because of the overhanging dorsal crest; ferruginous brown with darker brown markings; tegmina yellowish hyaline, tips faintly clouded with brown.

Head yellow, punctate with brown, sparingly pubescent, faintly sculptured; eyes prominent, brown; ocelli large, pearly, conspicuous, protruding, nearer to each other than to the eyes; clypeus flat, punctate, pubescent, lateral margins covered by small overlapping projections of the vertex.

Pronotum yellow, coarsely punctured, a black-brown fascia down median carina of metopidium, another at anterior base of dorsal crest on each side, and a brown band from posterior base of crest to lateral margin of pronotum; metopidium convex; humeral angles prominent, tipped with brown; dorsal crest projecting far forward over metopidium, anterior base strongly concave, posterior margin convex; posterior process long, slender, acuminate, about reaching apices of tegmina.

Tegmina yellow-hyaline, wrinkled, veins prominent, bases punctate, tips clouded with brown. Undersurface of thorax and abdomen fuscous. Legs yellow-ferruginous; tibiae hairy.

Length 11 mm.; width 6 mm.

35. *Telamona unicolor* Fitch (Plate XXVII, 9, 10, and Plate XLIV, 1)

1851 *Telamona unicolor* Fitch, Cat. Ins. N. Y., p. 50.
1851 *Telamona fasciata* Fitch, Cat. Ins. N. Y., p. 50.
1851 *Telamona unicolor* Walk., List Hom. B. M., p. 1146.
1851 *Telamona fasciata* Walk., List Hom. B. M., p. 1146.
1854 *Telamona unicolor* Emm., N. Y. Agr. Rept. 5:154, pl. 3, fig. 3.
1856 Fitch, Rept. Ins. N. Y. 3:450.
1856 *Telamona fasciata* Fitch, Rept. Ins. N. Y. 3:451.
1858 *Hemiptycha diffusa* Walk., List Hom. B. M. Suppl., p. 143.
1869 *Telamona unicolor* Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1877 Butler, Cist. Ent. 2:220, no. 1.
1877 *Telamona fasciata* Butler, Cist. Ent. 2:220, no. 3.
1886 Prov., Petite Faune Can. 3:244.
1886 *Telamona unicolor* Prov., Petite Faune Can. 3:244.
1890 Packard, Ins. Inj. For. and Shade Trees, p. 325.
1890 *Telamona fasciata* Packard, Ins. Inj. For. and Shade Trees, p. 325.
1890 Van Duzee, Psyche 5:388, 391.
1891 Osborn, Iowa Acad. Sci. 1²:128.
1892 *Telamona fasciata* et *unicolor* Godg., Ins. Life 5:93.
1894 *Telamona fasciata* Godg., Cat. Memb. N. A., p. 421.
1908 Van Duzee, Stud. N. A. Memb., p. 71.
1908 *Telamona unicolor* Van Duzee, Stud. N. A. Memb., p. 71, pl. 2, fig. 6.
1909 Smith, Ins. N. J., p. 92.
1909 *Telamona fasciata* Van Duzee, Can. Ent. 41:383.
1912 *Telamona unicolor* Matausch, Bul. Amer. Mus. Nat. Hist. 31:333, pl. 30, fig. 10.
1915 Funkh., Fitch's Types, p. 49, 50.
1915 Metcalf, Hom. No. Car., p. 7.
1916 Van Duzee, Check List Hem., p. 60, no. 1651.

Is fairly common on the hills southeast of Ithaca but has never been taken north of Six Mile Creek. Inhabits hickory, butternut, walnut, and basswood, but eggs and nymphs have been found only on hickory, on which host the life history of the insect has been worked out.

This species is one of the most active of all the Telamonas and flies well. The striking colors of both sexes makes the species easy of recognition. The females are a brilliant grass-green, while the males are yellow with brown fascia. Both fade quickly in collections. Attempts have been made to preserve the green color of the female but without success.

Eggs laid during September hatch about the middle of May and reach maturity the last of June. The males are much less numerous than the females thruout the season. Mating has been observed thruout August and September, and the nymphal periods have been found to average, respectively, ten, six, five, ten, and fourteen days.

A very fine stand of hickory, containing large numbers of this species, is found in Station O.

Technical description.— Females large, brilliant uniform grass-green; males smaller, bright yellow with deep brown fascia. Very striking in color; large size; crest high and square; tegmina tipped with brown.

Female: Head nearly twice as wide as long, green punctate with brown, finely pubescent; eyes large, brown; ocelli large, orange, nearer to each other than to the eyes; clypeus deeply punctate, pubescent, tip in a pointed extension.

Pronotum concolorous green, fading to mottled yellow in cabinet specimens; very finely punctate and pubescent; metopidium more or less angular, median carina distinct, three small brown spots mesad of humeral angles; humeral angles produced, triangular, blunt; crest large, high, much higher before than behind, anterior margin less sloping than posterior, dorsal margin brownish; posterior process long, gradually acute, apex brownish and not reaching tips of tegmina.

Tegmina brownish hyaline, bases and costal regions punctate with black, tips clouded with dark brown, veins prominent. Undersurface of thorax flavous, abdomen yellowish, pubescent, ovipositor brown. Legs flavous; tibiae mottled with brown; tarsi ferruginous.

Length 11 mm.; width 6 mm.

Male: Differs from female in size and color. Head mottled brown and yellow, much darker than that of female, much sculptured, inferior line of face strongly sinuate.

Pronotum bright yellow, metopidium strongly shaded with brown; dark brown fascia on front of dorsal crest; dark brown fascia on posterior third of crest extending gradually narrowed to lateral margin of pronotum; posterior median line of crest yellow, transverse band of yellow behind crest; apex of posterior process brown.

Undersurface of body deep brown. Legs flavous strongly marked with brown.

Length 10 mm.; width 5 mm.

36. *Telamona pruinosa* Ball

1903 *Telamona pruinosa* Ball, Proc. Biol. Soc. Wash. 16:177, pl. 1, figs. 7–7b.
1914 Van Duzee, Trans. S. Diego Soc. Nat. Hist. 2[1]:50.
1916 Van Duzee, Check List Hem., p. 60, no. 1642.

Rare. The only station for the species known in the basin is one small clump of young sycamores in the bed of upper Six Mile Creek. Nymphs and adults have been collected here, but the data obtained have not been sufficient to determine the life history. Both nymphs and adults feed on the petioles of the smaller leaves. The species is very active and flies well and for considerable distances, but eventually returns to the same host from which it was disturbed.

The species may be recognized by the uniform ferruginous color and by the very well-developed humeral angles.

Technical description.— Of the same general form as *T. ampelopsidis*, but smaller and differing in color; ferruginous brown with yellowish fascia over metopidium; posterior process exceeding tips of tegmina; tegmina brownish hyaline, tips slightly clouded.

Head uniform yellow-green, irregularly punctate, pubescent, sculptured; eyes prominent, light brown; ocelli prominent, protruding, brown with white margins, nearer to each other than to the eyes; clypeus flat, tip extended.

Pronotum coarsely punctate; metopidium convex, lower anterior margin yellow, smooth area above eyes, median dorsal carina prominent; humeral angles much produced, triangular, sharp; dorsal crest much higher before than behind, anterior margin vertical, dorsal margin sloping backward, posterior margin short; posterior process long, slender, acuminate, extending beyond tips of tegmina.

Tegmina brownish hyaline, bases and costal areas sparingly punctate, tips faintly clouded with brown. Undersurface of body and legs yellowish; tarsi yellow-ferruginous; claws fuscous.

Length 10 mm.; width 6.5 mm.

37. *Telamona decorata* Ball (Plate XXVII, 11, 12)

1903 *Telamona decorata* Ball, Proc. Biol. Soc. Wash. **16**:179, pl. 1, figs. 6, 6a.
1908 Van Duzee, Stud. N. A. Memb., p. 67.
1916 Van Duzee, Check List Hem., p. 60, no. 1637.

Common thruout the basin on red oak and linden and found during the entire summer. The species is very close to *T. reclivata*, from which it can be separated by the brown oblique marking extending from the tip of the crest to the lateral margin of the pronotum.

The adults are most commonly found on the smaller branches and the twigs, a habit noted by Dr. Ball in his original description. The nymphs have not been distinguished from those of *T. reclivata*, with which they are often associated.

Technical description.— Grayish yellow with sides of crest and line from crest to margin of pronotum brown; apex of posterior process broadly brown; tegmina smoky hyaline, bases sharply punctate with black, apices brown.

Head wider than long, nearly vertical, lemon yellow thickly punctured with brown, punctures larger and darker near eyes than in center; entire face sculptured; clypeal suture deep; eyes brown margined with paler; ocelli large, pearly, nearer to each other than to the eyes; clypeus extending well below inferior margin of cheeks, tip hirsute.

Pronotum thickly punctured, finely pubescent. Humeral angles pronounced, rounded, extending as far laterad beyond eyes as width of eyes; dorsal crest slightly wider than high, sloping both before and behind, sides deep brown with the color extending posterio-ventrad to lateral margin of pronotum, posterior line of crest yellow; median dorsal line percurrent, distinct, mottled before crest; posterior process not quite reaching tips of tegmina; apical end broadly brown, tip acute and black.

Tegmina smoky hyaline, veins very prominent, bases sharply punctate with black, apices brown. Undersurface of body yellowish; last segments of female darker. Outer surfaces of tibiae mottled with brown; claws fuscous.

Length 9 mm.; width 4.5 mm.

The genus Archasia Stål

The genus Archasia is an interesting one. Its species show the broad, compressed, leaf-like expansion of the pronotum suggestive of the tropical forms of the genus Membracis. The colors of the species in Archasia, however, are not brilliant, being usually green or brown with occasionally a decoration of black points along the dorsal margin.

Only two species of the genus are found in the United States, and of these one is found in the Cayuga Lake Basin. This is *A. Belfragei*, one of the few species of local Membracidae that are really representative of the family in general shape and appearance.

38. *Archasia Belfragei* Stål (Plate XXVII, 13)

1869	*Archasia Belfragei*	Stål, Bid. Memb. Kän., p. 250.
1894		Godg., Cat. Memb. N. A., p. 425.
1908		Van Duzee, Stud. N. A. Memb., p. 73.
1909		Smith, Ins. N. J., p. 92.
1913		Funkh., Hom. Wing Veins, figs. 40, 63.
1915		Metcalf, Hom. No. Car., p. 7.
1916		Van Duzee, Check List Hem., p. 60, no. 1662.

Rather common on oak and locust. Taken only on the east side of the lake, on the wooded slopes. Easily recognized by the very foliaceous pronotum. The nymphs have not been found and apparently do not inhabit the trees on which the adults are found. The life history has therefore not been worked out.

Technical description.— Green fading to yellowish in cabinet specimens; pronotum high, strongly foliaceous, dorsal margin brown; tegmina about half concealed by pronotum; posterior process not reaching apices of tegmina.

Head nearly twice as wide as long, smooth, sparingly pubescent; base high and sinuate; eyes very prominent, shining dark brown; ocelli pearly, prominent, nearer to each other than to the eyes.

Pronotum closely but weakly punctate, not pubescent; humeral angles small, triangular; dorsal crest very high, flattened, foliaceous, almost vertical above head, slightly concave

above head, posterior margin gradually hollowed out before apex of posterior process, entire dorsal margin flattened and uniformly brown.

Tegmina smoky hyaline, bases and costal margins punctate, tips strongly marked with brown. Undersurface of body yellow-brown; abdomen brown. Legs dull yellow-brown; tibiae pubescent.

Length 9 mm.; width 4.5 mm.; height of pronotum 5 mm.

The genus Smilia Germar

The genus Smilia somewhat resembles the preceding genus in that the pronotum is compressed and flattened; but it is easily distinguished by the fact that the terminal cell of the hind wing is triangular and petiolate. Only one species is recorded from the basin.

39. *Smilia camelus* Fabricius (Plate XXVII, 14)

1803 *Membracis camelus* Fabr., Syst. Rhyng., p. 10, no. 18.
1843 *Smilia vittata* A. & S., Hem., p. 539.
1846 *Thelia camelus* Fairm., Rev. Memb., p. 308, no. 7, pl. 5, figs. 5, 8, 9.
1851 . Walk., List Hom. B. M., p. 562.
1851 *Smilia vittata* Fitch, Cat. Ins. N. Y., p. 48.
1851 *Smilia guttata* Fitch, Cat. Ins. N. Y., p. 49.
1851 *Thelia vittata* Walk., List Hom. B. M., p. 1143.
1854 *Smilia guttata* Emm., N. Y. Agr. Rept. 5:153, pl. 3, fig. 11.
1854 *Smilia vittata* Emm., N. Y. Agr. Rept. 5:154, pl. 3, fig. 14.
1862 *Membracis camelus* Harris, Treatise, p. 220.
1862 *Smilia camelus* Uhler, Harris' Treatise, p. 220.
1869 Stål, Hem. Fab. 2:115.
1878 Glover, MS. Journ. Hom., pl. 2, fig. 22.
1884 Uhler, Stand. Nat. Hist., p. 225.
1889 Van Duzee, Can. Ent. 21:7.
1890 Smith, Ins. N. J., p. 441.
1891 *Smilia vittata* Osborn, Iowa Acad. Sci. 1^2:128.
1892 *Smilia camelus* Godg., Ins. Life 5:92.
1893 *Smilia betulae* Godg., Can. Ent. 25:196.
1893 *Smilia camelus* Godg., Can. Ent. 25:196.
1894 Godg., Cat. Memb. N. A., p. 426.
1894 *Smilia camelus* var. *viridis* Godg., Cat. Memb. N. A., p. 426.
1903 *Smilia camelus* Buckt., Mon. Memb., p. 218.
1905 *Senilia camelas* Kellogg, Amer. Ins., p. 168.
1908 *Smilia camelus* Van Duzee, Stud. N. A. Memb., p. 74.
1909 Smith, Ins. N. J., p. 12.
1910 *Smilia camelus* var. *silvestrii* Matausch, Journ. N. Y. Ent. Soc. 18:172.
1913 *Smilia camelus* Funkh., Hom. Wing Veins, figs. 42, 65.
1915 Funkh., Fitch's Types, p. 49.
1915 Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 60, no. 1664.

Common on oak and occasionally found on locust. Very active and flies well. Has been taken commonly in the northern part of the basin and rarely in the vicinity of Ithaca.

This is perhaps the most brilliantly marked of all the local species of Membracidae. The ground color of the high, flattened pronotum is brown — chocolate in the female and black-brown in the male — with a broad diagonal slash of bright nile green extending from the cephalic dorsal apex to the middle of the lateral margin.

Technical description.— Pronotum high and foliaceous, extending forward over the head; brown with broad diagonal stripe of green or yellowish followed by a parallel translucent band and a white spot; males much smaller and darker than females.

Head triangular, sculptured, yellow with scattered brown punctures and hairs; eyes brown; ocelli pearly, margins raised, nearer to each other than to the eyes; clypeus continuing inferior line of face, apex slightly produced.

Pronotum coarsely punctured, punctures farther apart in pale parts; wide green band extending from anterior dorsal angle of crest to lateral margin of pronotum, this band fading to yellowish in dried insects; wide translucent band from behind middle of dorsum to lateral base of crest; white spot at posterior base of crest; humeral angles hardly produced, short, rounded; posterior process short, pointed, not reaching tips of tegmina.

Tegmina hyaline, bases punctate with brown, apices brown. Undersurface of body brownish yellow. Legs flavous.

Length, female 9 mm., male 7–8 mm.; width, female 3 mm., male 2.5–3 mm.

The genus Cyrtolobus Goding

The genus Cyrtolobus is very large and widely distributed. The species are in great confusion and extremely hard to delimit. The specific characters generally used have been based on the shape and color of the pronotum, both of which are very variable indeed; so that a long series of specimens show gradations thru a number of species as at present recognized. The chief source of confusion arises in the fact that many of the species inhabit the same host (chiefly oak) and the nymphs are gregarious.

The genus as a whole may be distinguished by the compressed dorsum and the thin, semitransparent spot below the dorsal ridge. The colors are usually dull browns with many irregular markings.

Only a few species have been reared. It has been possible, however, to recognize ten apparently distinct species, which may be separated as follows:

a. Dorsum regularly rounded from head, without anterior notch .... *ovatus*
aa. Dorsum with anterior depression before elevation.
  b. Crest arising before humeral angles.
    c. Color uniform dark brown .... *fuliginosus*
    cc. Color pale yellow-red with brown oblique line .... *muticus*
  bb. Crest arising behind humeral angles.
    c. Large — at least 9 mm. in length .... *tuberosus*

cc. Small -- not over 7 mm. in length.
 d. Crest very low or obsolete.
  e. Elytra uniform clouded brown........................... *fuscipennis*
  ee. Elytra marked with whitish.................................. *cinereus*
 dd. Crest well developed.
  e. Pronotum distinctly marked with oblique bands.................... *vau*
  ee. Markings obscure or obsolete.
   f. Concolorous brown, immaculate........................ *intermedius*
   ff. Pronotum faintly marked with oblique ray.
    g. Elytra hyaline.. *cinctus*
    gg. Elytra clouded; tip broadly fuscous................. *discoidalis*

40. *Cyrtolobus ovatus* Van Duzee (Plate XXVIII, 1)

1908 *Cyrtolobus ovatus* Van Duzee, Stud. N. A. Memb., p. 82, pl. 2, fig. 14.
1909 Van Duzee, Flor. Hem., p. 207.
1909 Smith, Ins. N. J., p. 92.
1916 Van Duzee, Check List Hem., p. 60, no. 1668.

Very rare. A southern form, which apparently migrates occasionally into this basin. In July, 1913, one specimen was taken by the author while sweeping in a wooded pasture.

Technical description.— Sordid yellow-testaceous; dorsum regularly elliptical; head projecting slightly forward; posterior process high and carinate, exceeding apices of tegmina; tegmina hyaline, punctate at base.

Head extended forward, very convex, roughly and deeply punctate, not pubescent, yellow; base smoothly rounded; eyes prominent, brown, reaching external margin of adjoining edge of pronotum; ocelli small, pearly, about equidistant from each other and from the eyes; clypeus strongly convex, tip continuing rounded inferior margin of face, deeply punctate, apex hairy.

Pronotum roughly and deeply punctate, sparingly pubescent, sordid yellow-testaceous with faint or obsolete paler band at base of posterior process; humeral angles not prominent, rounded; dorsal crest high, sharp, compressed, unicolorous, margin regularly elliptical, compressed at anterior base, in the middle, and at posterior base, posterior compression translucent; posterior process high, sharp above, decidedly depressed, extending just beyond tips of tegmina.

Tegmina hyaline, unmarked, bases and costal areas slightly punctate. Undersurface of body and legs concolorous yellow; tibiae hairy.

Length 8 mm.; width 3 mm.

41. *Cyrtolobus fuliginosus* Emmons (Plate XXVIII, 2)

1854 *Cyrtosia fuliginosa* Emm., N. Y. Agr. Rept. 5:154, pl. 13, fig. 15.
1893 *Cyrtosia fuliginosus* Godg., Can. Ent. 25:172.
1893 *Cyrtolobus fuliginosus* Godg., Can. Ent. 25:172.
1894 Godg., Cat. Memb. N. A., p. 433.
1908 Van Duzee, Stud. N. A. Memb., p. 82.
1916 Van Duzee, Check List Hem., p. 60, no. 1669.

Common. Collected on white oak. Eggs and nymphs have not, however, been distinguished from those of other species of the genus living

on the same host. Peculiar because of its uniform dark brown color without markings.

Technical description.— Near preceding species in appearance, but smaller, darker, and with lower crest; dark sordid brown with faint transverse bands; head projecting slightly forward; posterior process just reaching tips of tegmina; tegmina strongly marked with brown, apices lighter.

Head somewhat extended forward, yellow, mottled with deep brown, deeply punctate with brown, not pubescent, a black spot at base of head above each ocellus; eyes large, brown, lighter in color than remainder of head; ocelli small, pearly, about equidistant from each other and from the eyes; clypeus convex, sculptured, a brown line on each side, tip continuing rounded inferior outline of face.

Pronotum dark brown, transverse fascia extending from anterior base of crest to lateral margin of pronotum, this fascia light brown before and very dark brown behind; entire pronotum deeply and densely punctate; humeral angles weak, angular but blunt; dorsal crest regularly arcuate from above humeral angles to base of posterior process; posterior process heavy, short, blunt, just reaching apices of tegmina.

Tegmina smoky brown, apical cells lighter, apical margins fuscous, bases and costal margins roughly punctate. Legs and undersurface of body flavous.

Length 6 mm.; width 2.5 mm.

42. *Cyrtolobus muticus* Fabricius (Plate XXVIII, 3)

1776	*Membracis mutica*	Fabr., Gen. Ins., p. 297, nos. 12, 13.
1781		Fabr., Spec. Ins. 2:318, no. 15.
1787		Fabr., Mant. Ins. 2:265, no. 25.
1788		Gmel., Ed. Syst. Nat. 2:2093.
1792		Oliv., Enc. Méth., p. 663, no. 11.
1794		Fabr., Ent. Syst. 4:15, no. 29.
1803	*Centrotus mutica*	Fabr., Syst. Rhyng., p. 21, no. 24.
1869	*Cyrtosia mutica*	Stål, Hem. Fab. 2:25.
1890		Van Duzee, Psyche 5:390.
1894	*Cyrtolobus muticus*	Godg., Cat. Memb. N. A., p. 431.
1908		Van Duzee, Stud. N. A. Memb., p. 83, pl. 2, fig. 16.
1909		Smith, Ins. N. J., p. 92.
1915		Metcalf, Hom. No. Car., p. 8.
1916		Van Duzee, Check List Hem., p. 61, no. 1695.

Very rare. One specimen now in Cornell collection taken at Ithaca on June 27, 1885, by an unknown collector, and one specimen collected on June 14, 1914, by H. H. Knight, are the only records for the basin. No data on hosts or life history.

Technical description.— Yellowish tinged with red; transverse band of pronotum often absent; pronotum long; head slightly projecting forward; eyes tinged with reddish; posterior process reaching tips of tegmina; tegmina entirely hyaline or faintly clouded with yellow.

Head slightly protruding forward, yellow with red punctures, sculptured, not pubescent; base irregularly sinuate; eyes gray marked with red; ocelli small, translucent, somewhat nearer to each other than to the eyes; clypeus swollen, convex, continuing inferior outline of face, tip slightly extended, hairy; antennae prominent.

Pronotum yellowish with irregular reddish areas, deeply and roughly punctate, not pubescent; transverse band when present pale with reddish borders; humeral angles weak, blunt;

PLATE XXVIII

1, Lateral outline of *Cyrtolobus ovatus* Van Duzee
2, Lateral outline of *Cyrtolobus fuliginosus* Emmons
3, Pronotum of *Cyrtolobus muticus* Fabricius
4, Pronotum of *Cyrtolobus tuberosus* Fairmaire
5, Pronotum of *Cyrtolobus discoidalis* Emmons
6, Pronotum of *Cyrtolobus cinctus* Van Duzee
7, Pronotum of *Cyrtolobus vau* Say; 8, last nymphal instar
9, Pronotum of *Cyrtolobus cinereus* Emmons
10, Pronotum of *Cyrtolobus fuscipennis* Van Duzee
11, Lateral outline of *Atymna castaneae* Fitch; 12, last nymphal instar
13, Lateral outline of *Atymna querci* Fitch
14, Lateral outline of *Atymna inornata* Say
15, Pronotum of *Cyrtolobus intermedius* Emmons
16, Pronotum of *Ophiderma pubescens* Emmons

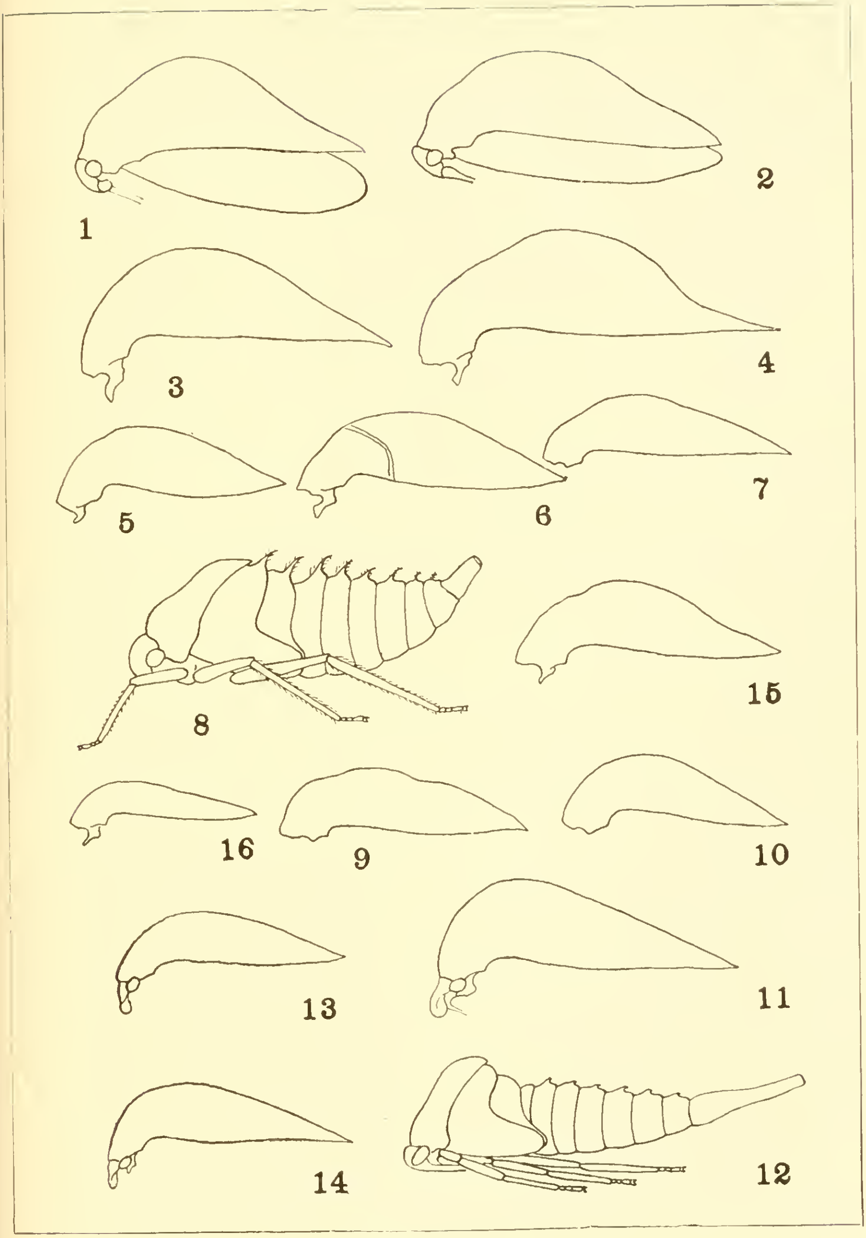


Plate XXVIII

dorsal crest elliptical, very slight sinus before base of posterior process, compressions not deep; posterior process heavy, blunt, just reaching tips of tegmina.

Tegmina hyaline or clouded with reddish yellow, tips pale, veins in some cases yellowish, bases and costal areas irregularly punctate. Legs and undersurface of thorax flavous; abdomen sordid yellow.

Length 6 mm.; width 2.8 mm.

43. *Cyrtolobus tuberosus* Fairmaire (Plate XXVIII, 4)

1846 *Thelia tuberosus* Fairm., Rev. Memb., p. 307, no. 6.
1851 Walk., List Hom. B. M., p. 562.
1894 *Cyrtolobus tuberosus* Godg., Cat. Memb. N. A., p. 433.
1908 Van Duzee, Stud. N. A. Memb., p. 84, pl. 2, fig. 18.
1915 Weiss, Ent. News **26**:102.
1915 Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 60, no. 1673.

Very common in the entire southern part of the basin, abundant about Danby and Spencer, and not uncommon about Ithaca. Has not, however, been taken in the basin north of Aurora. The species inhabits the white and red oaks and is occasionally found on hickory. The life history is fairly well known, but egg-laying has not been observed.

Cyrtolobus tuberosus is the largest species of the genus and is recognizable by this fact. The crest is high and the translucent spot which characterizes the genus is very large.

Technical description.— Largest species of the genus; brown mottled with darker brown; dorsal compression strikingly transparent; dorsal crest situated well back on pronotum, posterior process very short; tegmina smoky hyaline tipped with brown.

Head triangular, broader than long, ochraceous tinged with red and punctate with brown, not pubescent; base weakly sinuate; inferior margin of face strongly sinuate; eyes large, brown; ocelli small, yellowish, slightly protruding, nearer to each other than to the eyes; clypeus convex, brown line on each side, tip extended and hairy.

Pronotum deeply and closely punctate, light greenish brown; crest dark brown with pale compression at anterior base, in the middle, and at posterior base; middle compression very large and transparent, posterior half of crest dark brown with color extending in a dark band to margin of pronotum; metopidium very convex, median carina prominent; humeral angles prominent, rounded; posterior process short, sharp, brown, inferior lateral margin slightly sinuate, not reaching tips of tegmina.

Tegmina brownish hyaline, tips strongly marked with brown, bases punctate. Undersurface of thorax yellow. Legs ferruginous, hind trochanters marked with brown; tarsi flavous; claws brown.

Length 9.5 mm.; width 4 mm. Male smaller than female, but similarly colored.

44. *Cyrtolobus discoidalis* Emmons (Plate XXVIII, 5)

1854 *Gargara discoidalis* Emm., N. Y. Agr. Rept. **5**:157, pl. 13, fig. 4.
1864 *Smilia carinata* Stål, Hem. Mex., p. 71.
1867 *Cyrtosia carinata* Stål, Öfv. Kongl. Vet. Akad. Forh. **24**:554.
1893 *Cyrtolobus discoidalis* Godg., Can. Ent. **25**:172.
1894 *Atymna discoidalis* Godg., Cat. Memb. N. A., p. 436.

1896 *Atymna carinata* Fowler, B. C. A., p. 141.
1896 *Cyrtolobus discoidalis* Fowler, B. C. A., p. 141.
1903 Buckt., Mon. Memb., p. 192, pl. 41, fig. 8.
1908 Van Duzee, Stud. N. A. Memb., p. 86.
1909 Smith, Ins. N. J., p. 92.
1909 *Gargara discoidalis* Van Duzee, Flor. Hem., p. 209.
1915 *Cyrtolobus discoidalis* Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 60, no. 1676.

Very rare. One specimen in Cornell collection, taken at Ithaca on June 30, 1891, collector's name not indicated. No other record for the basin.

Technical description.— Yellowish marked with light brown; distinguished by a brown line on each side of metopidium beginning just back of humeral angles and continuing down over face; posterior process very short, not reaching tips of tegmina; tegmina yellow-hyaline, tips clouded with light brown.

Head slightly broader than long, yellow with brown fascia on each side, this fascia an extension of pronotal band, finely punctate, not pubescent; base weakly sinuate; inferior margin sharply angular, clypeus continuing outline of face to form apex of triangle; eyes very prominent, gray; ocelli small, yellowish, not prominent, about equidistant from each other and from the eyes; clypeus convex, faint brown line on each side, tip acute, hairy.

Pronotum yellow marked with light brown, transverse band pale bordered with light brown; entire pronotum regularly and deeply punctate; humeral angles not prominent; dorsal crest rather low, not strongly compressed; posterior process very short, blunt, apex extending just beyond internal angles of tegmina.

Tegmina yellow-hyaline, tips faintly clouded with brown, bases light brown and punctate. Undersurface of thorax ferruginous; abdomen flavous. Legs yellowish, femora marked with brown.

Length 6 mm.; width 2.8 mm.

45. *Cyrtolobus cinctus* Van Duzee (Plate XXVIII, 6)

1908 *Cyrtolobus cinctus* Van Duzee, Stud. N. A. Memb., p. 86.
1916 Van Duzee, Check List Hem., p. 60, no. 1677.

Fairly common on young white oaks in the vicinity of Rogues Harbor. Seldom taken in any other part of the basin. Recognized by the almost hyaline tegmina and the fine, obscure markings. Life history not known.

Technical description.— Female large, greenish with prominent curved pronotal stripe of dark brown; male small, very dark brown, markings obsolete.

Female: Head broader than long, pale green without markings, sculptured, roughly punctate, smooth depression above each ocellus; eyes large, red; ocelli small, pearly; inferior margin of face sinuate; clypeus extending below line of face.

Pronotum green fading to yellow, roughly punctate, transverse line narrow, curved, dark brown, prominent; dorsal crest not high, elliptical, compressed at upper margin; posterior process not reaching tips of tegmina.

Tegmina hyaline, bases greenish and punctate. Legs and undersurface of body yellow; tarsi ferruginous.

Length 6.8 mm.; width 2.5 mm.

Male: Head uniform dark brown, almost black; eyes gray; ocelli yellow and prominent; inferior margin of face regularly rounded.

Pronotum very dark brown, transverse band narrow and pale; pale band at base of posterior process.

Tegmina yellow-hyaline, bases greenish and punctate often marked with brown, veins in base prominent. Entire undersurface of body deep brown, almost black. Legs flavous.

Length 5.5 mm.; width 2 mm.

46. *Cyrtolobus vau* Say (Plate XXVIII, 7, 8)

1831 *Membracis vau* Say, Journ. Acad. Nat. Sci. Phila. 5:299.
1842 Harris, Treatise, p. 178.
1851 *Thelia semifascia* Walk., List Hom. B. M., p. 561.
1851 *Smilia vau* Fitch, Cat. Ins. N. Y., p. 48.
1851 *Thelia vau* Walk., List Hom. B. M., p. 1142.
1856 *Smilia vau* Fitch, Rept. Ins. N. Y. 3:541.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:541.
1859 *Membracis vau* Say, Compl. Writ. 2:378.
1862 Harris, Treatise, p. 220.
1862 *Smilia vau* Uhler, Harris' Treatise, p. 220.
1877 Glover, Rept. U. S. Dept. Agr., p. 30, fig. 20.
1877 Uhler, Wheeler's Rept. App. J, no. 1333.
1878 Glover, MS. Journ. Hom., pl. 2, figs. 10, 31.
1886 *Cyrtosia vau* Prov., Petite Faune Can. 3:238.
1889 Van Duzee, Can. Ent. 21:7.
1890 Van Duzee, Psyche 5:389.
1890 *Smilia vau* Smith, Ins. N. J., p. 441.
1891 *Cyrtosia vau* Osborn, Iowa Acad. Sci. 1^2:128.
1892 Harring, Ottawa Nat. 6:30.
1892 Godg., Ins. Life 5:92.
1893 *Cyrtolobus nigra* Godg., Can. Ent. 25:172.
1893 *Cyrtolobus punctifrontis* Godg., Can. Ent. 25:172.
1893 *Cyrtolobus tricincta* Godg., Can. Ent. 25:172.
1893 *Cyrtolobus vau* Godg., Can. Ent. 25:172.
1894 Godg., Cat. Memb. N. A., p. 432.
1895 Gillette and Baker, Hem. Colo., p. 67.
1903 *Thelia fasciata* Buckt., Mon. Memb., p. 189.
1903 *Argante semifasciata* Buckt., Mon. Memb., p. 189, pl. 40, fig. 9, and pl. 41, figs. 1, 1a.
1903 *Cyrtolobus vau* Buckt., Mon. Memb., p. 218.
1908 Van Duzee, Stud. N. A. Memb., p. 87, pl. 2, fig. 19.
1909 Smith, Ins. N. J., p. 92.
1909 *Cyrtolobus varius* Smith, Ins. N. J., p. 92.
1909 *Cyrtolobus vau* Van Duzee, Can. Ent. 41:384.
1913 Funkh., Hom. Wing Veins, figs. 43, 66.
1915 Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 61, no. 1678.

Extremely abundant thruout the basin. The commonest species of Cyrtolobus in the region. Found on almost all varieties of oaks and occasionally on chestnut. The entire life history is passed on one host. The eggs are laid in the late fall, and winter over, and two broods a year appear in some seasons. The nymphs are plentiful and easily distinguished. The species is recognized by its small size and very characteristic markings.

Eggs laid during September hatch about the middle of May and the insects reach maturity the last of June. Males are much less numerous than females thruout the season. Mating has been observed thru August and September, and the nymphal periods have been found to average, respectively, ten, six, five, ten, and fourteen days.

A very fine stand of hickory containing a few oaks near the top of South Hill has proved a good station for the species, but the best collecting ground in the basin has been Station B, particularly the small grove just east of the old street-car right of way. Here the nymphs appear about June 1 and the adults are plentiful by the middle of July. The nymphal skins are very noticeable on the undersides of the leaves, and the exuviae are very perfect. A large number of such exuviae have been collected on July 11, which date marks the height of the last molting season. Mating occurs a few days after the adults reach maturity, and oviposition begins during the same week. Some of the eggs hatch in the same season, making two broods a year for certain years. This depends, however, on climatic conditions.

Technical description.— Small robust species, with low pronotum and prominent markings; varies greatly in color and somewhat in size; females larger and lighter than males, but with constant markings; transverse pronotal band prominent, pale bordered with deep brown; dorsal compression deep and translucent; posterior process short, blunt, not reaching tips of tegmina; tegmina hyaline, with bases and tips slightly brown.

Head small, subtriangular, pale yellow punctured with brown; base feebly sinuate; inferior margin of face sinuate, clypeus extending slightly below line; eyes large, gray-brown; ocelli small, yellowish, somewhat nearer to each other than to the eyes; clypeus hairy.

Pronotum closely and roughly punctate, median compressed spot round, transparent; dorsal crest low, arising above humeral angles and gradually extending with only a faint sinus before posterior process; posterior process short, blunt, tectiform, reaching to bases of apical cells of tegmina.

Tegmina hyaline, veins prominent, bases and apices smoky hyaline. Legs and undersurface of body uniform flavous.

Length 5.5–6.5 mm.; width 2.4–2.6 mm.

47. *Cyrtolobus intermedius* Emmons (Plate xxviii, 15)

1854 *Cyrtosia intermedia* Emm., N. Y. Agr. Rept. 5: pl. 13, fig. 16.
1894 *Cyrtolobus intermedius* Godg., Cat. Memb. N. A., p. 433.
1908 Van Duzee, Stud. N. A. Memb., p. 90.
1916 Van Duzee, Check List Hem., p. 61, no. 1683

Not common, and hard to delimit. The color is chestnut brown and if constant should be a good superficial character. The insect is of medium size, but the limited amount of material available for study makes it

impossible to state the degree to which it may vary. Nothing is known of its life history.

Technical description.— Uniform chestnut in color; pronotum low and gradually arcuate; compressions not deep; posterior process short, straight, not reaching tips of tegmina; tegmina hyaline, bases brown and punctate.

Head subtriangular, convex, yellow or chestnut deeply punctured with brown, not pubescent; base weakly sinuate; inferior margin of face forming with the clypeus a nearly right angle; eyes prominent, greenish gray; ocelli small, pearly, about equidistant from each other and from the eyes; clypeus deeply punctate with brown, pubescent, tip hairy.

Pronotum densely punctate, not pubescent; humeral angles weak, rounded; metopidium convex, median carina prominent; dorsal crest low, not greatly compressed, compressed spots shallow; posterior process short, triangular, extending to bases of apical cells of tegmina.

Tegmina hyaline, bases light brown and punctate. Legs and undersurface of thorax and abdomen flavous tinged with ferruginous, abdomen mostly flavous.

Length 6.5 mm.; width 2.5 mm.

48. *Cyrtolobus cinereus* Emmons (Plate XXVIII, 9)

1854 *Gargara cinereus* Emm., N. Y. Agr. Rept. 5:156.
1893 *Cyrtolobus cinereum* Godg., Can. Ent. 25:172.
1894 *Atymna cinereum* Godg., Cat. Memb. N. A., p. 436.
1908 *Cyrtolobus cinereus* Van Duzee, Stud. N. A. Memb., p. 91.
1909 Smith, Ins. N. J., p. 92.
1916 Van Duzee, Check List Hem., p. 61, no. 1686.

Rare. A small series in the Cornell University collection, and a pair taken by the author on July 3, 1914, are the only specimens known from the locality. The host is probably oak, but nothing is known of the life history of the species.

Technical description.— Small greenish gray mottled with brown and banded with green; pronotum low and regularly arcuate; metopidium convex; posterior process short but sharp; tegmina wrinkled, hyaline, apices brown.

Head convex, pale grayish green sharply punctate with black, sparingly pubescent; base nearly straight; eyes prominent, brown; ocelli large, reddish, prominent, slightly farther from each other than from the eyes and situated slightly below an imaginary line extending thru centers of eyes; clypeus flat, somewhat trilobed, a faint brown line on each side, extending below inferior margin of face.

Pronotum green-gray tinged with reddish, closely punctate, not pubescent; dorsal crest very low, median spot on margin pale; a transverse pale band bordered with brown extending from anterior base of crest backward and downward to lateral margin of pronotum, a similar band extending from base of posterior process downward and forward to almost meet the anterior stripe and form a V with it; posterior process short, not reaching tips of tegmina.

Tegmina wrinkled, hyaline, brown spot at base of each, another in middle, and a third at tip; areas between hyaline. Legs and undersurface of body grayish flavous.

Length 5.8 mm.; width 2.5 mm.

49. *Cyrtolobus fuscipennis* Van Duzee (Plate XXVIII, 10)

1908 *Cyrtolobus fuscipennis* Van Duzee, Stud. N. A. Memb., p. 91.
1909 Smith, Ins. N. J., p. 92.
1916 Van Duzee, Check List Hem., p. 61, no. 1687.

Very rare. Van Duzee's paratypes in the Cornell collection, and a small series taken by the author in July, 1914, are the only records.

Technical description.— Near preceding species in appearance, but larger and with tegmina strongly colored with reddish brown and marked with darker; pronotum low; posterior process short.

Head gray-green deeply punctate with black, areas next to eyes black; base nearly straight; eyes large, gray; ocelli large, red, prominent, about equidistant from each other and from the eyes; clypeus long, extending below inferior margin of face.

Pronotum deeply and closely punctate, sparingly pubescent, green-gray tinged with reddish; metopidium convex, median carina distinct, large brown fascia above each eye; dorsal crest very low, median spot pale; anterior transverse line pale bordered with brown; similar line before base of posterior process; posterior process short, blunt, not reaching apices of tegmina.

Tegmina deep red-brown, semiopaque, darker brown spot at middle and at tip of each, bases punctate. Undersurface of thorax red-brown; abdomen flavous. Legs ferruginous.

Length 6 mm.; width 2.4 mm.

The subgenus Atymna Stål

The subgenus Atymna of the genus Cyrtolobus has been set off to include those forms in which the pronotum is highest at the anterior extremity. The character, while entirely superficial, is valuable for convenience in separating the species of this confusing group.

The three species represented in the basin may be separated as follows:

a. Species large, 7–9 mm . . . . *castaneae*
aa. Species small, 5–6 mm.
  b. Pronotum punctate; female green, male black with broken yellow dorsal stripe . . . . *querci*
  bb. Pronotum smooth; both sexes green . . . . *inornata*

50. *Atymna castaneae* Fitch (Plate xxviii, 11, 12)

1851 *Smilia castaneae* Fitch, Cat. Ins. N. Y., p. 49.
1851 *Thelia castaneae* Walk., List Hom. B. M., p. 1143.
1854 *Gargara nigricephala* Emm., N. Y. Agr. Rept. 5:157, pl. 13, fig. 5.
1854 *Gargara viridis* Emm., N. Y. Agr. Rept. 5:154, pl. 3, fig. 13.
1856 *Smilia castaneae* Fitch, Rept. Ins. N. Y. 3:470.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:470.
1858 Walk., List Hom. B. M. Suppl., p. 133.
1867 *Atymna castaneae* Stål, Öfv. Kongl. Vet. Akad. Forh. 24:554.
1869 *Smilia castaneae* Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1890 *Atymna castaneae* Van Duzee, Psyche 5:390.
1890 *Smilia castaneae* Packard, Ins. Inj. For. and Shade Trees, p. 350.
1890 *Ophigenna nigrocephala* Smith, Ins. N. J., p. 442.
1892 *Atymna castaneae* Harring, Ottawa Nat. 6:30.
1894 Godg., Cat. Memb. N. A., p. 435.
1894 *Ophiderma nigricephala* Godg., Cat. Memb. N. A., p. 440.
1896 *Atymna castaneae* Fowler, B. C. A., p. 140.
1903 Buckt., Mon. Memb., p. 194, 218.
1903 *Atymna lineata* Buckt., Mon. Memb., p. 194, pl. 42, fig. 6.

1908 *Cyrtolobus* (*Atymna*) *castaneae* Van Duzee, Stud. N. A. Memb., p. 93.
1909 Smith, Ins. N. J., p. 92, 93.
1913 Funkh., Hom. Wing Veins, fig. 44.
1915 Funkh., Fitch's Types, p. 49.
1915 Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 61, no. 1690.

A characteristic species on chestnut, abundant wherever this tree is common. The nymphs appear in large numbers about the second week in June and the adults about a month later. Both feed on petioles and blades of young leaves. There is apparently but one brood a year. The season for collecting this species is short, since the insects are abundant for only about two weeks and then disappear. The insects of *Atymna castaneae* have the best power of flight of any of the local membracids, and this is about the only species ever taken about electric lights.

The forms vary remarkably in size and coloration. This peculiar variation does not seem to be sexual or seasonal and its cause is not known. Three forms are quite distinct — one large light immaculate green, another large very dark brown, and a third small light castaneous with very dark brown elytra. Some differences have been noted between the nymphs that develop into these various forms, but not enough to warrant a taxonomic distinction.

A peculiar feature in the life history of this membracid is the fact that altho the insects are very abundant during the first two weeks in July they are seldom found after that date locally. This period seems to be an incredibly short one for the adult life of the insect, and yet it has not been taken on any other host later in the season.

The species is abundant on the chestnut trees just east of the insectary along the Forest Home road, and in certain parts of the valley of Six Mile Creek.

Technical description.— Extremely variable as to both size and color; of the rather constant varieties the one that is most abundant may be described as follows:

Castaneous with dark brown patch over each humeral angle and dorsal margin lined with brown; crest highest above humeral angles, sloping gradually to apex of posterior process; posterior process short, not reaching apices of tegmina; tegmina deep castaneous, brown at base and tip.

Head somewhat protruding, convex, sculptured, sparingly punctate, not pubescent, yellow marked with brown; base nearly straight; eyes prominent, gray-brown; ocelli not prominent, white, about equidistant from each other and from the eyes; clypeus long, narrow, extending for half its length below inferior margin of face.

Pronotum castaneous marked with brown over humeral angles, dorsal margin tinged with brown; entire pronotum coarsely punctured, not pubescent; humeral angles not prominent, rounded; dorsal crest highest above humeral angles, gradually sloping backward, dorsal

line straight; posterior process short, tectiform, gradually acute, not reaching bases of apical cells of tegmina.

Tegmina very dark, basal two-thirds deep brown, almost black, apices strongly marked with brown, narrow area between these two brown regions hyaline. Undersurface of prothorax marked with brown; abdomen and legs flavous.

Length 6.5 mm.; width 2 mm.

51. *Atymna querci* Fitch (Plate XXVIII, 13)

1851 *Smilia querci* Fitch, Cat. Ins. N. Y., p. 49.
1851 *Thelia querci* Walk., List Hom. B. M., p. 1143.
1854 *Gargara querci* Emm., N. Y. Agr. Rept. 5:156, pl. 13, fig. 8
1878 *Smilia querci* Glover, MS. Journ. Hom., pl. 2, fig. 11.
1890 *Atymna querci* Van Duzee, Psyche 5:390.
1891 Osborn, Iowa Acad. Sci. 1²:128.
1894 Godg., Cat. Memb. N. A., p. 435.
1908 *Cyrtolobus (Atymna) querci* Van Duzee, Stud. N. A. Memb., p. 93.
1912 *Cyrtolobus querci* Matausch, Bul. Amer. Mus. Nat. Hist. 31:335, pl. 31, fig. 14.
1915 *Atymna querci* Funkh., Fitch's Types, p. 49.
1915 Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 61, no. 1692.

Very common on oak and often taken on other hosts in the neighborhood of oaks. Since the insects are strong flyers it is probable that their appearance on the other trees is accidental. The eggs and the nymphs are found only on the oak — principally the white oak — which doubtless accounts for the specific name. The species is found thruout the summer.

The insects of this species are smaller than those of *A. castaneae*. The females are uniform green with the pronotum closely punctate; the males brown with a light golden stripe down the median dorsal line, this stripe being broken near the posterior end of the pronotum so that the whole marking appears as a long dash followed by a dot.

Technical description.— Females large and green, males smaller and brown with a broken yellow median dorsal stripe; body long and narrow; crest highest above humeral angles and gradually sloping to posterior apex without a sinus.

Female: Head projecting slightly forward, pale yellow, sculptured, irregularly punctate, not pubescent; eyes very prominent, reddish; ocelli not prominent, yellow; clypeus extending below inferior margin of face.

Pronotum uniform green, roughly punctate, not pubescent, dorsal line faintly marked with brown; posterior process short, acute, not reaching tips of tegmina.

Tegmina entirely hyaline, bases and costal margins faintly punctate; hind wings iridescent. Legs and undersurface of body green.

Length 7 mm.; width 2.5 mm.

Male: Head sordid yellow, sculptured, sparingly punctate; eyes prominent, brown; ocelli pearly; clypeus marked with brown at base.

Pronotum chocolate brown with bright yellow stripe on median dorsal line and yellow band before apex.

Tegmina smoky hyaline with brown cloud at apices. Undersurface of thorax brownish; abdomen very dark brown, nearly black. Legs flavous; tarsi ferruginous; claws fuscous.

Length 6 mm.; width 2 mm.

52. *Atymna inornata* Say (Plate XXVIII, 14)

1831 *Membracis inornata* Say, Journ. Acad. Nat. Sci. Phila. 5:299
1851 *Smilia inornata* Fitch, Cat. Ins. N. Y., p. 48.
1851 *Thelia inornata* Walk., List Hom. B. M., p. 1142.
1856 *Smilia inornata* Fitch, Rept. Ins. N. Y. 3:471.
1856 Fitch, Trans. N. Y. Agr. Soc. 16:471.
1858 Walk., List Hom. B. M. Suppl., p. 134.
1859 *Membracis inornata* Say, Compl. Writ. 2:578.
1869 *Smilia inornata* Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1877 Glover, Rept. U. S. Dept. Agr., p. 30, fig. 18.
1878 Glover, MS. Journ. Hom., pl. 2, fig. 26.
1882 *Atymna inornata* Lintner, First Rept. Ins. N. Y., p. 284.
1886 *Ophiderma inornata* Prov., Petite Faune Can. 3:248.
1890 *Atymna inornata* Van Duzee, Psyche 5:389.
1890 Packard, Ins. Inj. For. and Shade Trees, p. 350.
1891 *Atymia inornata* Osborn, Iowa Acad. Sci. 1²:128.
1892 *Atymna inornata* Godg., Ins. Life 5:92.
1894 Godg., Cat. Memb. N. A., p. 434.
1908 *Cyrtolobus (Atymna) inornata* Van Duzee, Stud. N. A. Memb., p. 93.
1909 *Atymna inornata* Smith, Ins. N. J., p. 93.
1915 Metcalf, Hom. No. Car., p. 8.
1916 Van Duzee, Check List Hem., p. 61, no. 1693.

Not common. The smallest of the species of the genus. Both sexes are green but the species may be recognized by the smooth polished surface of the pronotum and the very fine punctures. Occurs on most species of oaks. Has been taken at the north end of the lake and less frequently about Ithaca. The species is often found associating with *A. querci*.

Technical description.— Small, green, polished, shining, punctures fine and shallow; dorsum weakly, gradually rounded; posterior process pointed, not reaching apices of tegmina; tegmina entirely hyaline.

Head vertical, convex, flavous, nearly smooth, obsoletely punctured, not pubescent; eyes gray; ocelli pearly, farther from each other than from the eyes; clypeus smooth, convex.

Pronotum uniform green or fading to sordid yellow in dried specimens, shining, polished, very closely and finely punctured; metopidium low, median carina prominent; humeral angles not prominent; dorsal crest low, highest just behind humeral angles, feebly arcuate, median edge compressed; posterior process gradually acute, reaching just beyond bases of apical cells of tegmina.

Tegmina hyaline, veins yellowish, bases faintly punctate, apical marginal borders wrinkled. Legs and undersurface of body flavous.

Length 6 mm.; width 2.2 mm.

The subgenus Xantholobus Van Duzee

Like Atymna, the subgenus Xantholobus has been arbitrarily erected for convenience in separating the numerous forms of the genus Cyrtolobus. It is delimited to include those forms in which the posterior part of the

pronotum is strongly inflated to produce a rounded swelling. Before this swelling the dorsum is constricted.

The two species found in the basin may be separated as follows:

a. Pronotum with three irregular oblique lines . . . . *trilineatus*
aa. Pronotum with single yellow line at lateral margin . . . . *lateralis*

53. *Xantholobus trilineatus* Say (Plate XXIX, 1)

1824 *Membracis trilineatus* Say, Narr. Long's Exp. App., p. 300.
1859 Say, Compl. Writ. 1:200.
1886 *Cyrtosia trilineata* Prov., Petite Faune Can. 3:239.
1890 Van Duzee, Psyche 5:389.
1892 Harring, Ottawa Nat. 6:30.
1894 *Cyrtolobus trilineatus* Godg., Cat. Memb. N. A., p. 432.
1908 *Cyrtolobus* (*Xantholobus*) *trilineatus* Van Duzee, Stud. N. A. Memb., p. 96, pl. 2, fig. 23.
1913 *Xantholobus trilineatus* Funkh., Hom. Wing Veins, figs. 45, 67.
1916 *Xantholobus muticus* Van Duzee, Check List Hem., p. 61, no. 1695.

Common. Usually taken on oaks, on which it shows the same general habits as the species of the genus Cyrtolobus. Easily recognized by the much swollen posterior pronotum.

Technical description.— Varies considerably in size and color, and somewhat in shape of posterior swelling; generally large, robust, pronotum much swollen behind middle; brown with pale vittae bordered with black; posterior process not reaching tips of tegmina; tegmina smoky hyaline.

Head subtriangular, yellow, punctured and marked with brown, roughly sculptured; base nearly straight; apical margin with clypeus rectangular; eyes prominent, round; ocelli distinct, brown, about equidistant from each other and from the eyes; clypeus large, sutures distinct, punctate with brown, a brown vertical band on each side, tip continuing inferior margin of face.

Pronotum brown with a pale fascia down center of metopidium, another extending from anterior base of dorsal swelling to lateral margin of pronotum, and a third at base of posterior process; each of these fascia broad, pale, and bordered on each side with black; dorsal swelling beginning well behind humeral angles, distinctly bilobed, compression between lobes pale; posterior process short, stout, extending about to bases of apical cells of tegmina; entire pronotum coarsely and densely punctate, not pubescent.

Tegmina smoky hyaline, bases black and punctate, veins dark at base and in middle. Undersurface of head and thorax black; abdomen flavous. Legs ferruginous; claws fuscous.

Length 7–8 mm.; width 3–4 mm.

54. *Xantholobus lateralis* Van Duzee (Plate XXIX, 2)

1908 *Cyrtolobus* (*Xantholobus*) *lateralis* Van Duzee, Stud. N. A. Memb., p. 96.
1916 Van Duzee, Check List Hem., p. 61, no. 1696.

Very rare. Van Duzee's unique type specimen, which is now in the Cornell collection, was taken on June 30, 1891, and no specimens have since been collected in the basin. The species is apparently common

PLATE XXIX

1, Pronotum of *Xantholobus trilineatus* Say
2, Pronotum of *Xantholobus lateralis* Van Duzee
3, Pronotum of *Ophiderma salamandra* Fairmaire
4, Last nymphal instar of *Ophiderma pubescens* Emmons
5, Pronotum of *Ophiderma flava* Goding
6, Pronotum of *Ophiderma flavicephala* Goding
7, Last nymphal instar of *Vanduzea arquata* Say; 8, adult; 9, lateral outline of pronotum; 10, enlarged lateral outline of last nymphal instar
11, Pronotum of *Entylia bactriana* Germar; 12, last nymphal instar
13, Pronotum of *Publilia concava* Say; 14, last nymphal instar

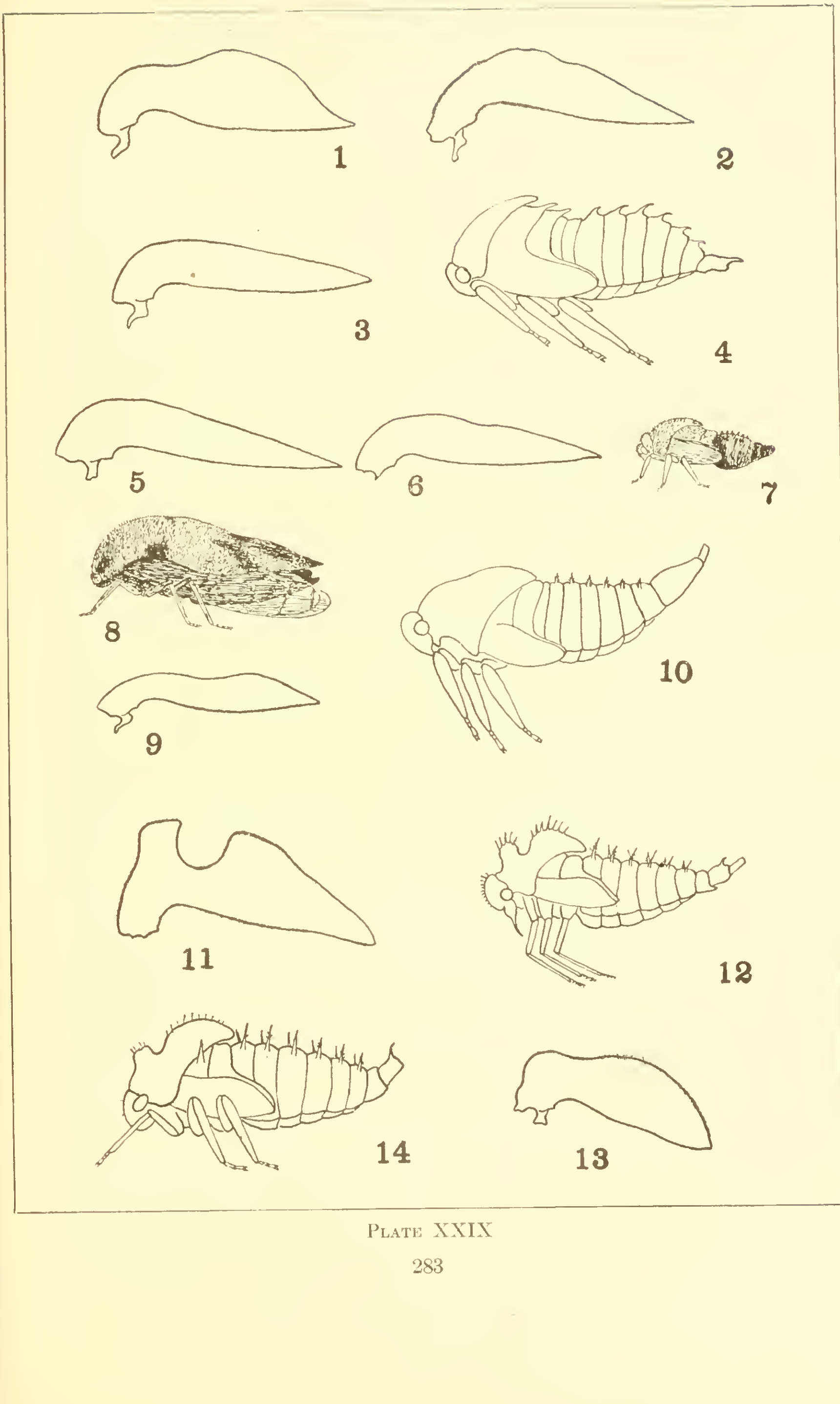


Plate XXIX

farther south and numerous specimens have been received from Pennsylvania. It is easily recognized by the bright yellow band which bounds the lateral margin of the pronotum in both sexes. Nothing is known of its habits or life history.

Technical description.— Females large, light brown; males small, very dark brown; lateral margin of pronotum in both sexes bordered with yellow; body long and narrow; posterior swelling not pronounced; posterior process not reaching tips of tegmina; tegmina smoky hyaline, clouded with fuscous at tips and showing dark abdomen thru middle.

Head yellow spotted with brown, weakly punctate, not pubescent; base rounded; eyes prominent, brown; ocelli not prominent, transparent; clypeus long, rectangular, apex dark brown.

Pronotum uniform brown with lateral band of yellow, densely and coarsely punctate; metopidium convex, median carina prominent; posterior swelling not large, indistinctly bilobed, median compression narrow; posterior process short, sharp, tectiform, extending to about middle of apical cells of tegmina.

Tegmina smoky hyaline, bases irregularly punctate, tips clouded with fuscous, veins prominent and brown. Undersurface of head and thorax brown; abdomen flavous with sides dark brown. Legs flavous-ferruginous.

Length 7.5 mm.; width 3 mm.

The genus Ophiderma Fairmaire

A genus distinguished in that the compressed, rounded dorsum shows no evidences of a ridge or crest. Most of the species are very hairy.

The genus is represented in the basin by four species, which may be separated as follows:

a. Color green or yellowish green . . . . *flava*
aa. Color brown or brown-mottled.
  b. Pronotum with broad yellow lateral stripe . . . . *flaviecphala*
  bb. Lateral stripe absent.
    c. Large, 7–8 mm . . . . *salamandra*
    cc. Small, 5–6 mm . . . . *pubescens*

55. *Ophiderma salamandra* Fairmaire (Plate XXIX, 3)

1846	*Ophiderma salamandra*	Fairm., Rev. Memb., p. 493, no. 1.
1851		Walk., List Hom. B. M., p. 588.
1856		Fitch, Rept. Ins. N. Y. 3:465.
1856		Fitch, Trans. N. Y. Agr. Soc. 16:465.
1890		Smith, Ins. N. J., p. 442.
1891		Osborn, Iowa Acad. Sci. 1^2:128.
1893		Hopkins, W. Va. Agr. Exp. Sta. Bul. 32:231.
1894		Godg., Cat. Memb. N. A., p. 438.
1903		Buckt., Mon. Memb., p. 196, 218.
1908		Van Duzee, Stud. N. A. Memb., p. 99.
1909		Van Duzee, Flor. Hem., p. 207.
1909		Smith, Ins. N. J., p. 93.
1916		Van Duzee, Check List Hem., p. 61, no. 1700.

The largest and commonest species of Ophiderma in the basin. Found on oaks. Very active and extremely difficult to study in the field. The life history is not known.

Technical description.— Large brown species; dorsum rounded and very pubescent with short, black, bristly hairs; posterior process short, suddenly acute, not reaching apices of tegmina; tegmina hyaline, bases and costal areas strongly punctate, tips clouded with fuscous, veins very prominent; underpart of body dark; males smaller and darker than females.

Head broader than long, yellow, feebly punctate, very hairy; base slightly, uniformly curved; eyes large, brown; ocelli prominent, red, nearer to each other than to the eyes; inferior margin of face sinuate; clypeus yellow with two vertical stripes of red; base hairy.

Pronotum coarsely punctate, densely pubescent, brown mottled with green; dorsum rounded, slightly depressed behind middle, lateral margin curved downward at middle; posterior process short, suddenly acute, not reaching tips of tegmina.

Tegmina smoky hyaline, veins very prominent, nearly all of basal half below pronotum strongly punctate, tips clouded with fuscous; hind wings iridescent. Undersurface of head and thorax fuscous; abdomen flavous. Femora and tibiae strongly marked with dark brown.

Length 7.6 mm.; width 3.2 mm.

56. *Ophiderma pubescens* Emmons (Plate XXVIII, 16, and Plate XXIX, 4)

1854 *Gargara pubescens* Emm., N. Y. Agr. Rept. 5: 157, pl. 13, fig. 2.
1908 *Ophiderma pubescens* Van Duzee. Stud. N. A. Memb., p. 99.
1913 Funkh., Hom. Wing Veins, figs. 46, 68.
1916 Van Duzee, Check List Hem., p. 61, no. 1701.

A small and very hairy species, very abundant in all parts of the basin. It is common on oak early in the season. The nymphs appear in April and may be taken until July. Like those of the preceding species, the insects show great activity and are not often taken in general collecting.

Technical description.— Small, light brown mottled with white; dorsum convex, hairy; posterior process short and blunt, not reaching tips of tegmina; tegmina hyaline with median black stripe and cloud of brown on tips; undersurface of body flavous; femora strongly marked with black; males smaller and darker than females.

Head broader than long, yellow tinged with red and punctate with brown, sculptured, convex; base sinuate; eyes prominent, grayish; ocelli protruding, transparent, about equidistant from each other and from the eyes; clypeus extending below inferior margin of face, feebly trilobed, two vertical stripes of red, tip hairy.

Pronotum closely and finely punctate, densely pubescent, light brown with broad pale stripe down center of metopidium, middle of this stripe dark brown, semicircular white stripe behind humeral angles and another before base of posterior process, these stripes sometimes bordered with darker; humeral angles not prominent; metopidium convex; dorsum convex, very slightly depressed behind middle; posterior process short, suddenly acute, extending as far as bases of apical cells of tegmina.

Tegmina mottled, basal fifth of each brown and punctate, behind this an opaque yellow, punctate, transverse band, this followed by a transverse black band, apical two-fifths hyaline; tips clouded with fuscous. Undersurface of body flavous. Legs flavous, femora strongly marked with black.

Length 6 mm.; width 2.5 mm.

57. *Ophiderma flavicephala* Goding (Plate xxix, 6)

1892	*Ophiderma flavicephala*	Godg., Ins. Life 5:92.
1894		Godg., Cat. Memb. N. A., p. 439.
1908		Van Duzee, Stud. N. A. Memb., p. 100, pl. 2, fig. 28.
1909		Van Duzee, Flor. Hem, p. 207.
1909		Smith, Ins. N. J., p. 93.
1910	*Ophiderma flavocephala*	Matausch, Journ. N. Y. Ent. Soc. 18:169.
1915	*Ophiderma flavicephala*	Metcalf, Hom. No. Car., p. 8.
1916		Van Duzee, Check List Hem., p. 61, no. 1703.

Rare. Only a few records for the basin. Host not known, probably oak. Species recognized by the lateral yellow line on or near the margin of the pronotum.

Technical description.— Brown with yellow lateral stripes; densely pubescent and punctate; pronotum broadly convex, gradually sloping from humeral region; posterior process almost reaching tips of tegmina; tegmina hyaline, bases and tips brown.

Head much broader than long, finely punctate, sparingly pubescent with long hairs, yellow with a small black spot above each ocellus; ocelli prominent, brilliant red; inferior margin of face strongly sinuate; clypeus broad, extending below margin of face.

Pronotum densely punctate and pubescent, hairs long; uniform brown with yellow stripe beginning at head and extending two-thirds of length of pronotum; dorsum rounded, slightly depressed in middle; posterior process acute, almost reaching tips of tegmina.

Tegmina coriaceous and opaque, distal half of each brown, apical half hyaline; tips brown. Undersurface of thorax fuscous; abdomen flavous. Trochanters and femora strongly marked with black.

Males slightly smaller and much darker than females, with much heavier pubescence especially on anterior part of pronotum.

Length 5.5–6 mm.; width 2–2.5 mm.

58. *Ophiderma flava* Goding (Plate xxix, 5)

1892	*Ophiderma flava*	Godg., Ins. Life 5:93.
1893		Godg., Can. Ent. 25:172.
1894		Godg., Cat. Memb. N. A., p. 439.
1908		Van Duzee, Stud. N. A. Memb., p. 100.
1909		Smith, Ins. N. J., p. 93.
1915		Metcalf, Hom. No. Car., p. 8.
1916		Van Duzee, Check List Hem., p. 61, no. 1704.

Rare. Has been taken occasionally by beating low shrubs and bushes. Particular host not known. The eggs and the nymphs have not been recognized. The adult insect may be at once recognized by the uniform light green or greenish yellow color.

Technical description.— Large greenish yellow species, fading to sordid yellow in cabinet specimens; body robust and long; posterior process not reaching apices of tegmina; tegmina hyaline, brown at base and fuscous-clouded at tips.

Head much broader than long, green, weakly and sparingly punctate, smooth, shining, sparingly pubescent; eyes large, red; ocelli prominent, reddish, about equidistant from each other and from the eyes; clypeus smooth, nearly black, base regularly rounded, tip extending below inferior margin of face.

Pronotum uniform green, in some cases tinged with reddish, closely and densely punctate, finely pubescent; dorsum rounded, depressed behind middle, median carina percurrent; posterior process heavy, tectiform, acute, not extending to tips of tegmina.

Tegmina hyaline, bases reddish and punctate, tips clouded with fuscous, veins heavy and inclined to be punctate along margin. Legs and undersurface of body entirely flavous.

Length 7–8 mm.; width 3–4 mm.

The genus Vanduzea Goding

The genus Vanduzea is close to Ophiderma but is distinguished by the terminal cell of the elytra, which in Vanduzea is transverse and truncate at the base.

The genus is entirely North American and five species have been described from various parts of the United States. Only one of these species is found locally, but this is the commonest membracid in the basin.

59. *Vanduzea arquata* Say (Plate XXIX, 7–10)

1831 *Membracis arquata* Say, Journ. Acad. Nat. Sci. Phila. 5:302.
1851 *Carynota arquata* Fitch, Cat. Ins. N. Y., p. 48.
1851 Walk., List Hom. B. M., p. 1144.
1859 *Membracis arquata* Say, Compl. Writ. 2:380.
1869 *Caranota arcuata* Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1878 *Carineta arquata* Glover, MS. Journ. Hom., pl. 2, fig. 24.
1890 *Ophiderma arquata* Van Duzee, Psyche 5:389.
1890 Smith, Ins. N. J., p. 442.
1892 *Vanduzea arquata* Godg., Ins. Life 5:92.
1893 *Ophiderma arquata* Godg., Can. Ent. 25:172.
1894 *Vanduzea arquata* Godg., Cat. Memb. N. A., p. 440.
1895 Gillette and Baker, Hem. Colo., p. 68.
1903 *Vanduzea arcuata* Buckt., Mon. Memb., p. 218.
1908 *Vanduzea arquata* Van Duzee, Stud. N. A. Memb., p. 103, pl. 2, fig. 30.
1909 Smith, Ins. N. J., p. 93.
1909 *Carynota arcuata* Van Duzee, Can. Ent. 41:382.
1910 *Vanduzea arquata* Matausch, Journ. N. Y. Ent. Soc. 18:169.
1912 Matausch, Bul. Amer. Mus. Nat. Hist. 31:325, pl. 32, fig. 16.
1913 Branch, Kans. Univ. Sci. Bul. 8:106, figs. 14, 15, 68, 69, 78.
1913 Funkh., Hom. Wing Veins, figs. 6, 7, 9, 20, 28, 47, 69.
1915 Metcalf, Hom. No. Car., p. 9.
1915 Funkh., Psyche 22:183–198, pl. 17.
1916 Van Duzee, Check List Hem., p. 61, no. 1709.

Extremely abundant. Easily the commonest species of Membracidae in the region. Three or four broods a year on locust. The nymphs and the adults are present in great numbers thruout the summer, and the specimens may be collected by thousands from young locust trees in all

parts of the basin. The life history has been worked out in detail (Funkhouser, 1915 f).

There are three rather distinct seasons for egg-laying — one about the middle of June, one the last of July, and one in September. The eggs are laid during the summer at the base of bud scales of the preceding year, and in the fall in the buds. They are laid in clusters of from three to six eggs, in a finger-like mass. About one month is required for the processes of mating, oviposition, incubation, and hatching of the summer eggs, and about twenty days for the development of the nymphs. The greatest number of adults therefore appear early in June from the eggs that winter over, and the middle of July, the last of August, and the middle of October from the summer eggs. The periods, however, are more or less irregular and all nymphs do not mature at an equal rate, so that the immature forms of all stages may be found during the greater part of the summer.

Technical description.— Female: Light chocolate brown with deep brown and yellow-white markings, pubescent, punctate, without pronotal horns; dorsum regularly rounded, sharp at posterior apex; tegmina hyaline, cloudy at base and near middle, extending beyond posterior process, costal areas punctate, terminal cells with straight transverse base; legs and under-surface of body uniform luteous.

Head wider than long, yellow-brown, slightly punctate and sparingly pubescent; eyes prominent, dark brown; ocelli pearly white, equidistant from each other and from the eyes and situated on a line drawn thru centers of eyes; antennae short, three-jointed, the last segment fine and hairlike; clypeus extending slightly below marginal line of lorae when viewed from front, sparingly pilose; beak reaching behind coxae.

Pronotum finely punctate, pubescent, gradually rounded above head; humeral angles rounded, not prominent, extending beyond eyes to a distance equal to width of eyes; faint, percurrent, median carina; posterior process strong, acute, sharp at tip, extending as far as terminal cells of tegmina; color of pronotum yellowish brown with markings of dark brown and white, irregular brown spots on front of pronotum over eyes; diagonal light band extending on each side from apex of metopidium to lateral margin, this band having a dark brown posterior border; broad transverse light band just before posterior apex, this band bordered before and behind with dark brown.

Tegmina subhyaline, extending beyond apex of posterior process of pronotum; basal areas fuscous, punctate; costal cells punctate for almost the entire length; fuscous cloud in middle of each tegmen continuing dark pattern of pronotum above.

Underside of abdomen orange-yellow; sheath of ovipositor yellow. Pectoral regions and legs uniform yellow; femora pubescent; tibiae pubescent and armed with very small, black-tipped spines; tarsi fuscous; claws ferruginous.

Length including tegmina, 5.7 mm.; width between humeral angles, 2.6 mm.

Male: Smaller and darker than female, and having dorsal line slightly depressed just behind middle as seen from lateral outline; color deep brown, almost black; fasciae narrow, but conspicuous because of dark color around them.

Tegmina with veins very heavy and black. Undersurface of abdomen dark brown, segments margined with white. Legs uniform dark brown; femora smooth; tibiae with yellowish pubescence; tarsi and claws fuscous.

Length 4.6 mm.; width 2.3 mm.

The genus Entylia Germar

To the genus Entylia a very large number of species have been assigned, the standing of many of which is questionable. The genus is distinguished by the high, flattened dorsum with the deep median notch. One species is represented in the basin, but this species shows so much variation that it has been recorded under a number of names.

The whole genus is indeed in much confusion. Matausch (1910 c) has claimed that most of the species assigned to the genus, together with the species of the genus Publilia, are synonymous. Recent experiments by the writer, which will form the subject of a later report, tend to show that this is not entirely the case but that undoubtedly many of the species are not valid. The species *E. bactriana* as here recognized is, however, believed to be good.

60. *Entylia bactriana* Germar (Plate xxix, 11, 12)

1835 *Entylia bactriana* Germ., Silb. Rev. 3:248.
1846 Fairm., Rev. Memb., p. 300, no. 4, pl. 5, fig. 32.
1851 Walk., List Hom. B. M., p. 547.
1851 *Entylia indecisa* Walk., List Hom. B. M., p. 549.
1851 *Entylia reducta* Walk., List Hom. B. M., p. 549.
1858 *Entylia impedita* Walk., List Hom. B. M. Suppl., p. 137.
1869 *Entylia bactriana* Stål, Bid. Memb. Kän., p. 241.
1877 Butler, Cist. Ent. 2:211, no. 2.
1877 *Entylia reducta* Butler, Cist. Ent. 2:211, no. 5.
1894 *Entylia bactriana* Godg., Cat. Memb. N. A., p. 397.
1903 *Entylia reducta* Buckt., Mon. Memb., p. 185.
1903 *Entylia bactriana* Buckt., Mon. Memb., p. 185.
1908 *Entylia reducta* Van Duzee, Stud. N. A. Memb., p. 105.
1908 *Entylia bactriana* Van Duzee, Stud. N. A. Memb., p. 105.
1909 Smith, Ins. N. J., p. 93.
1913 Funkh., Hom. Wing Veins, fig. 48.
1915 Metcalf, Hom. No. Car., p. 9.
1916 *Entylia carinata* Van Duzee, Check List Hem., p. 61, no. 1716.

Very abundant in the lower parts of the basin, on thistle. Appears in July and August in such large numbers that it is often possible to take several hundred specimens from one plant. Nymphs and adults may be taken thruout the summer and the life history may be easily studied.

The species shows so much variation in color and in the shape of the pronotum that it is hard to choose the typical form. At least four forms that have been described as distinct species have been reared by the author from one egg mass.

The species has been taken commonly on thistle and is found on practically all the species of this plant growing in the basin. It also lays its eggs and undergoes its entire life history on joe-pye weed (*Eupatorium purpureum* L.) and on sunflower.

The eggs are laid in a double row on the underside of the leaf, one row on each side of the midrib. The eggs are very small and white and the ends project slightly from the surface. The number of eggs varies considerably and is often much larger in one row than in another. Oviposition requires about an hour. The process has first been observed on July 1. The eggs hatch in about two weeks and the nymphs reach maturity in a little over three weeks, the instars averaging about five days each. The nymphs of the first two instars remain very quietly on the leaf just above the eggs from which they have emerged, and the three other instars are hardly less quiet, remaining crowded on the leaf and showing little activity even when disturbed. After the last molt the insects are very soft-bodied and are generally white; the nymphal skins remain hanging to the tomentose surface of the leaf. In a few hours the insects begin to change color and creep about over the plant. The colors vary greatly, ranging from white to black. The insects are very sluggish and make no attempt to fly, but drop to the ground when disturbed. The number that may be found on one host plant is surprising, 232 having been taken from one thistle on August 21, 1913. They usually crowd closely together on the underside of the leaf, with their heads pointing toward the base of the leaf. Mating and oviposition take place soon after the insect reaches maturity. The second period of oviposition occurs about the last week in August and the nymphs from these eggs mature before cold weather sets in.

Miss Branch (1913) has recorded that the species *E. sinuata* undergoes but four molts in Kansas, and believes that molting cannot be accomplished without the presence of attending ants. Neither of these points has held true for the local species. The insect shows the usual five instars and successfully reaches maturity in the breeding cage when no ants are present.

Locally there are two broods a year. So far as has been ascertained, no eggs winter over but the winter is passed in the adult stage. Sifting in the late fall and early spring shows adults in the humus beneath the plants, which become active when brought into warm surroundings.

Coy's Glen and the surrounding hills have proved one of the best stations for the species.

Technical description.— Varies greatly in color, markings, and shape of pronotum, particularly in form and position of dorsal sinus; small, usually grayish or yellowish, unicolorous or marked with black or brown, in some cases almost entirely black; head projecting forward; dorsal crest high and distinctly bilobed with a rounded notch between lobes; posterior process heavy and blunt; tegmina almost entirely hidden under pronotum.

Head as long as broad, densely and coarsely punctate, not pubescent; base sinuate; inferior margin strongly sinuate; varying in color from gray to black; eyes wider than long, not prominent; ocelli prominent, often reddish, about equidistant from each other and from the eyes; clypeus wider than long, convex, coarsely punctate, sparingly pubescent, tip broadly rounded.

Pronotum high, compressed, distinctly bilobed; anterior lobe rising almost vertically above and before humeral angles, two strong ridges on each side extending from apex downward below base, apex usually truncate, higher behind than before; posterior lobe longer than anterior, rounded at tip, two ridges, more or less distinct, on each side; notch between lobes varying in size and shape but always rounded at bottom; sides of pronotum bearing ridges — usually three — extending from humeral angles to near posterior apex; pale fascia usually present at base of posterior lobe, extending to lateral margin of pronotum; posterior process heavy, blunt, extending beyond tips of tegmina; lateral areas of pronotum variously marked but usually showing the transverse fascia.

Tegmina almost entirely covered by pronotum; exposed costal areas opaque and densely punctate for more than half their length at base, tips hyaline. Undersurface of head fuscous; thorax and abdomen varying in color. Legs concolorous, usually flavous.

Length 5 mm.; width 2.5 mm.

The genus Publilia Stål

The standing of the genus Publilia has been questioned, and it has been suggested that the species assigned to this genus do not show characters distinct enough to be classed as generic. The forms as delimited show a much less elevated crest and a much weaker median notch than those of Entylia.

61. *Publilia concava* Say (Plate XXIX, 13, 14)

1824 *Membracis concava* Say, Narr. Long's Exp. App., p. 311.
1835 *Entylia concava* Germ., Silb. Rev. 3:249.
1842 *Membracis concava* Harris, Treatise, p. 178.
1846 *Entylia concava* Fairm., Rev. Memb., p. 301, no. 5.
1851 Walk., List Hom. B. M., p. 547.
1851 Fitch, Cat. Ins. N. Y., p. 47.
1851 Walk., List Hom. B. M., p. 1142.
1854 Emm., N. Y. Agr. Rept. 5:153, pl. 13, fig. 10.
1859 *Membracis concava* Say, Compl. Writ. 1:200.
1862 *Entylia concava* Uhler, Harris' Treatise, p. 220.
1866 *Publilia concava* Stål, Analecta Hem., p. 388.
1869 *Ceresa concava* Rathvon, Momb. Hist. Lanc. Co. Pa., p. 551.
1876 *Publilia concava* Uhler, List Hem. West Miss. River, p. 344.
1877 *Entylia concava* Glover, Rept. U. S. Dept. Agr., p. 24.

1878 *Entylia concava* Glover, MS. Journ. Hem., pl. 1, fig. 1.
1886 Prov., Petite Faune Can. 3:233.
1886 *Publilia concava* Prov., Petite Faune Can. 3:245.
1890 Smith, Ins. N. J., p. 441.
1891 Osborn, Iowa Acad. Sci. 1[2]:128.
1892 Godg., Ins. Life 5:92.
1894 *Publilia nigridorsum* Godg., Cat. Memb. N. A., p. 399.
1903 *Entylia concava* Buckt., Mon. Memb., p. 184, pl. 39, fig. 4, 4a.
1903 *Publilia vittata* Buckt., Mon. Memb., p. 185, pl. 39, fig. 6.
1903 *Publilia concava* Buckt., Mon. Memb., p. 194, pl. 42, fig. 5.
1908 *Publilia concava* var. *nigridorsum* Van Duzee, Stud. N. A. Memb., p. 106.
1908 *Publilia concava* Van Duzee, Stud. N. A. Memb., p. 106.
1909 Smith, Ins. N. J., p. 93.
1910 Matausch, Journ. N. Y. Ent. Soc. 18:169.
1913 Funkh., Hom. Wing Veins, fig. 49.
1915 Metcalf, Hom. No. Car., p. 9.
1916 Van Duzee, Check List Hem., p. 62, no. 1719.

Rare. Occasionally taken on goldenrod, on which host it is very abundant in other parts of the State.

The species may be recognized by the slight dorsal depression and the general rounded shape of the pronotum, characters which separate it from *Entylia bactriana*, the only other species with which it is likely to be confused. Like *E. bactriana* this species shows variation in color and in pronotal development.

H. H. Knight has taken this species in large numbers at Batavia, New York, from goldenrod. Nymphs and adults furnished by Mr. Knight have been successfully transferred to the same host plant in Ithaca, where they throve well and yielded complete life-history data. No eggs were laid in the late fall, and it is presumed that this species, like the one preceding, winters over in the adult stage. This presumption is borne out by the fact that Harold Morrison has collected adults at Freeville on May 29 (in 1913), a date that would be too early to admit of development from the egg.

The variety *nigridorsum* of Goding (Goding, 1894) is found with the typical forms of the species and is not here considered as distinct.

Technical description.— Varies greatly in color and somewhat in shape, particularly in form of dorsal sinuation; color varies from gray to black; dorsum convex, tectiform, faintly ribbed, dorsal sinus shallow; pronotum irregularly ridged, deeply punctate; tegmina largely covered by pronotum, basal half of each costal area strongly punctate.

Head slightly projecting, strongly punctate with black; base nearly straight; inferior margin rounded; eyes not prominent; ocelli prominent, usually reddish; clypeus rounded, very wide at tip.

Pronotum deeply, densely, and coarsely punctate, lateral areas marked with high, distinct, irregular, longitudinal ridges; dorsal margin sinuate just behind humeral angles, sinuation

usually very shallow; posterior lobe gradually elliptical to posterior apex; posterior process heavy, high, tectiform, blunt, extending just beyond tips of tegmina.

Tegmina almost entirely concealed by pronotum; exposed costal margins opaque and punctate for basal half, apical areas hyaline, tips fuscous. Undersurface of body and femora usually very dark, generally black. Legs flavous.

Length 5 mm.; width 2.5 mm.

OTHER SPECIES

In addition to the foregoing sixty-one species, which have actually been taken in the basin, there are two others that should be mentioned as forms which should occur in this region but have never been reported.

The first of these is *Ceresa albescens* VanD., which is found commonly thruout the State but has never been taken locally. The species is easily recognizable by its brown markings, and resembles a small, pale *C. diceros.* The usual host plants are blackberry and raspberry. The species has been taken in large numbers in the Saranac Lake region.

The second species which may appear in the basin, and which if found will clear up a mooted point in synonymy, is *Telamona collina* Walk. Up to the present this name has practically stood for a lost species, since the original description is so poor as to make absolute recognition impossible. Thru the courtesy of W. L. Distant, however, the writer has been able to procure an excellent figure of Walker's type specimen, drawn by Horace Knight, of London. This is here published (Plate XLIV, 2, page 409), in the hope that it may lead to the ultimate recognition of the species. It will be noted that the species bears a strong superficial resemblance to *T. pruinosa* Ball, and it may be that the latter will prove to be a synonym.

TAXONOMIC POSITION OF HOMOPTERA

The taxonomic position of the families of the Homoptera, and indeed the validity of the systematic divisions themselves, have long been a subject of discussion among hemipterists and the solution of the problem is not yet in sight. Without taking up in detail the points on which the workers fail to agree, it may be noted that in the division into families the Anchenorhynchi alone are credited by Comstock with four families, while Kirkaldy breaks up these four families into twelve divisions, all with family rank. In the discussion of phylogeny Osborn and Van Duzee place the Jassidae in the highest position, while Hansen and Kirkaldy

make the Fulgoridae the culmination of the phylogenetic table. Stål, whose taxonomic work was of the highest order, considers each of the modern families as subfamilies, while McGillivray and Baker rank each as a superfamily with the present subfamilies raised to family position. Valuable contributions have been made to the subject by Reuter, Sahlberg, Goding, Froggatt, Ashmead, Buckton, and Distant, but no two authorities agree on the correct taxonomic arrangement.

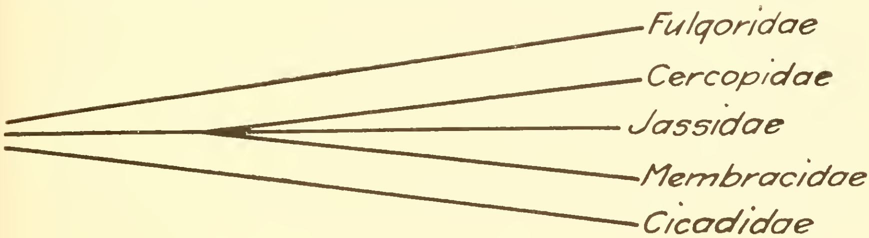
Without entering into an elaborate discussion of the subject, it seems reasonable at the present stage of knowledge to accept Amyot and Serville's group Anchenorhynchi as including that division of the Homoptera to which the Membracidae belong; and to agree with Osborn that the Cicadidae are the lowest of the families in this division and with Kirkaldy that the Fulgoridae are the most highly specialized. Hansen's very logical conclusion that the phylogenist should take into consideration the importance of the form of the antennae and the structure of their sensory organs, gives the Membracidae a low place in such a table and makes improbable Ashmead's assignment of the family to a position next to the Fulgoridae.

The phylogenetic comparisons made in the course of this study would tend to indicate that the Membracidae and the Cicadidae, while closely related, have arisen from different systems; that the Jassidae and the Cercopidae have been derived from the same stem as the Membracidae but are above the membracids in degree of specialization; that the Fulgoridae have arisen from an entirely different stem from any of the aforementioned groups and are far more highly specialized; and that the Psyllidae, usually considered as belonging to the separate group Sternorhynchi, are much closer to the Membracidae than has generally been supposed.

The families under consideration, then, would be arranged as follows in the order of their phylogenetic rank, beginning with the lowest:

1. Cicadidae
2. Membracidae
3. Jassidae
4. Cercopidae
5. Fulgoridae

The strict diagrammatic arrangement, however, would show the position of the families as follows:



In defense of the low position here assigned to the Membracidae the following points may be offered:

1. The entire sensory system is most poorly developed. The antennae are so minute as to be in most cases hardly visible and are but feebly provided with sensory apparatus. The responses of the insects to stimuli are exceedingly slow or entirely wanting.

2. The wings are extremely generalized. In a former paper by the writer (Funkhouser, 1913:92) it has been shown that the Membracidae are in this respect even lower than the Cicadidae, which Comstock and Needham (1899:213) have pronounced the most conservative of the Hemiptera so far as concerns venation of the wings.

3. The genital organs are simple. Little progress has been made in developing these structures from the ancient type.

4. The pronotum, to be sure, is highly specialized, but it is not logical to weigh these modifications of purely mechanical structures against the more important phylogenetic evidence offered by the sensory, motor, and reproductive systems.

EXTERNAL ANATOMY OF THE MEMBRACIDAE

In a taxonomic study of the Homoptera the structure and homology of the various sclerites of the exoskeleton have in many groups furnished an excellent basis for classification. The following division of this study is therefore offered in the thought that a knowledge of such structures in the family Membracidae might prove valuable in systematic work, and as an explanation in detail of the structures used as characters in the preceding section in which technical descriptions are given.

The rank of the Membracidae among the other Homoptera is, as has been stated, a mooted point. The exceptional and bizarre development of certain thoracic regions seemingly represents an extreme degree of specialization; the poorly developed nervous system, on the other hand, suggests a low position in the scale of the Hemiptera. It is believed that a comparison of the sclerites of the family with those of other homopterous forms may throw some light on the question of general homologies and serve to aid in the correct interpretation of structural development.

To make this report of the greatest value, the forms studied have not been limited to the species of the basin, but material has been drawn from all parts of the world. About two hundred species, representing about forty genera, have been examined, and for many of the species nymphal and imaginal material has been compared.

TECHNIQUE

In most cases the insects were boiled in caustic potash, dehydrated and cleared, and studied unmounted under the binocular. It was often found necessary to cut the body wall down the median dorsal line and mount the exoskeleton, opened out flat, in balsam under a large cover slip. The head was usually mounted separately, since the angle at which the head joins the thorax in the Membracidae makes a mount of the complete skeleton unsatisfactory. Small forms, spread under pressure, made excellent slides for study under the compound microscope. The method suggested by Crawford (1914:4), of sectioning away half of an embedded specimen with the microtome and dissolving the paraffin from the unsectioned half, gave good results but was not found necessary for most forms. Without exception the last nymphal instar, when obtainable, showed best the delineations of the sclerites. This was probably due to the fact that at this stage of development the exoskeleton is not entirely chitinized and the regions between the sclerites are therefore exaggerated.

For comparative study the gross dissections were checked by the use of microtome serial sections, both cross and longitudinal. In this method the insects (fresh material) were carried thru the following series: Brasil's fluid (cold), 12 hours; 70-per-cent alcohol (wash), 24 hours; stain in toto borax carmine, 72 hours; destain 70-per-cent acidulated alcohol, 24 hours; 85-per-cent alcohol, 24 hours; 95-per-cent alcohol, 24 hours; absolute alcohol and cedar oil, 24 hours; cedar oil, 48 hours; section from 6 to 10 μ;

benzine, 5 minutes; 95-per-cent alcohol, 5 minutes; 3-per-cent lyons blue, 20 seconds; 95-per-cent alcohol, 3 minutes; carbol-xylol, 5 minutes; mount in balsam.

No attempt has been made in this study to work out the musculature, altho it has been necessary to refer to certain developments of the skeleton which function as points of muscle attachment.

TERMINOLOGY

The terminology used in the discussion of the sclerites of the head follows that of Comstock and Kochi (1902), based on those of Kirby (1802), Illiger (1806), and Newport (1839).

For the thorax the terminology follows that of Crampton (1909) and that of Snodgrass (1909). Both of these follow largely the old work of Auduin (1820).

The terminology used in the discussion of the abdomen follows that of Berlese (1909).

GENERAL STRUCTURE

The exoskeleton in the Membracidae is strongly but not uniformly chitinized. The head and the thorax, particularly the latter, are hard to the point of brittleness; but in the abdomen and in those parts of the meso- and the metathorax that are covered by the pronotum, the impregnation of chitin is much less heavy.

The exposed parts of the cuticle — in the Membracidae much of the actual body surface is not exposed but is covered by the pronotal developments — are modified by remarkable and grotesque punctuations, ridges, and areolations (Plate xxx, 1–8), the function of which is conjectural. The commonest decoration consists of irregular arrangements of punctures, varying in size and distribution but fairly constant in appearance. In fact, this punctuation, whether deep or light, fine or coarse, dense or scant, has been used by practically all systematic workers on the group, and there can be no question as to the taxonomic value of such structures at least as specific characters. These punctures are merely depressions, or pits, extending into or even thru the cuticle but in no case perforating the entire body wall. They apparently have no connection with tracheal or glandular development and must be regarded as being merely superficial sculpturing. Occasionally the pits give rise to hairs. This is, however.

PLATE XXX

1–8, Types of sculpturing in Membracidae

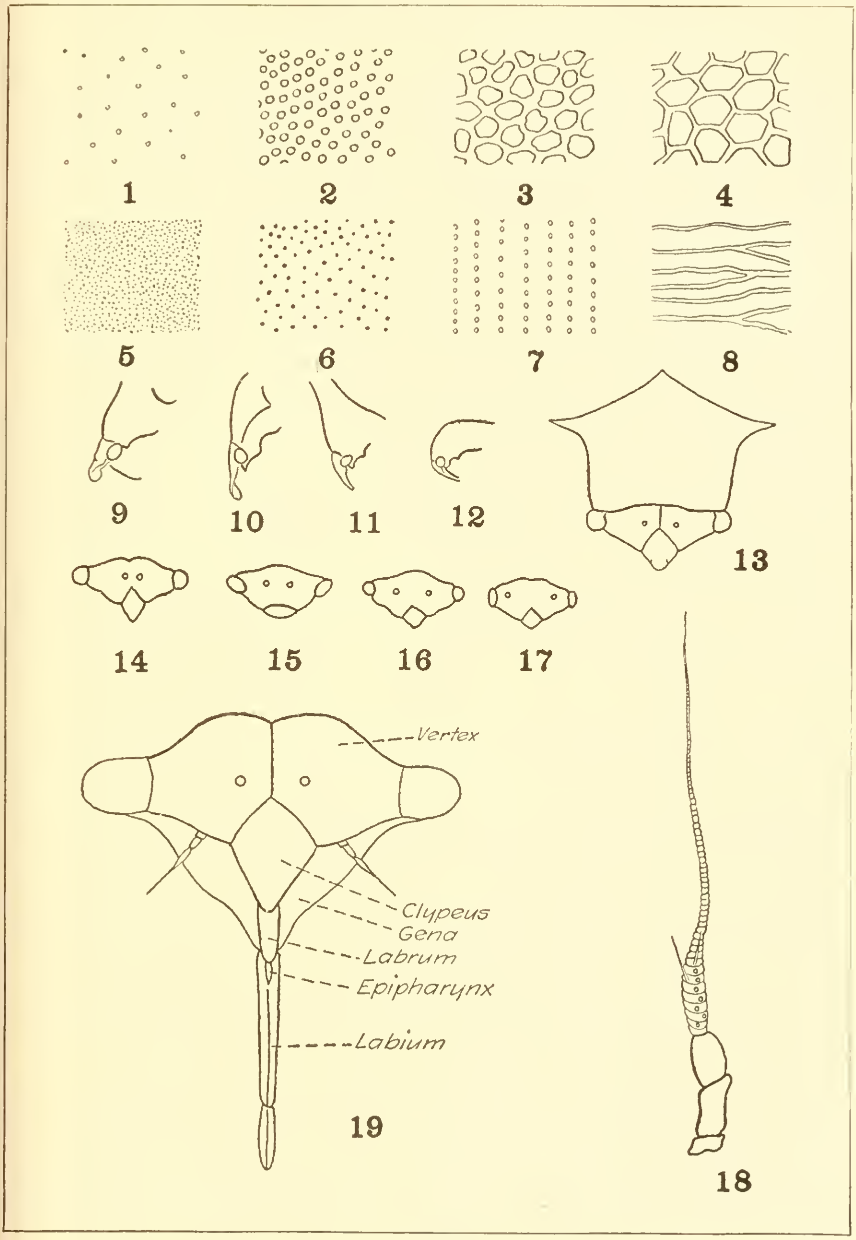
9, Position of head in *Entylia bactriana* Germar; 10, in *Ceresa bubalus* Fabricius; 11, in *Enchenopa binotata* Say; 12, in *Gargara nigrofasciata* Stål

13, Typical frontal view of membracid head

14, Position of ocelli in *Heteronotus strigosa* Butler; 15, in *Darnis partita* Walker; 16, in *Hyphinoe cornuta* Distant; 17, in *Nassunia bispina* Fairmaire

18, Structure of antenna

19, Cephalic view of head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16
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18
19
Vertex
Clypeus
Gena
Labrum
Epipharynx
Labium

PLATE XXX

of no significance so far as the association between the two structures is concerned, since in the very pubescent species the hairs arise as abundantly from between the punctures as from their centers. Moreover, many strongly punctate forms are entirely without hairs, while many hairy forms are entirely without punctures. The association of the two, therefore, is believed to be accidental.

Pubescence of various types is common thruout the family. It varies from thick, tangled mats to sparsely occurring thin hairs. Such growth occurs oftenest on the sides of the meso- and the metathorax and on the lateral areas of the pronotum. Special regions that are inclined to pubescence are noted in the discussion of the segments concerned.

The colors of the exoskeleton are in the main somber and dull. As might be expected from the phytophagous habits of the insects, the usual colors run to greens, yellows, and browns. The body colors are generally brown and black. A few tropical species show rather gaudy markings of red, yellow, and orange, and these colors occasionally appear in the nymphs. The colors in general, even the brighter ones, are permanent, with the exception of the various shades of green, which fade in cabinet specimens. Most colors, except the greens, change but little when the specimens are preserved in alcohol.

THE HEAD

In its essential parts the head of the membracid differs little from those of other Homoptera. It varies within the family in size and shape of the sclerites, but shows little variation in their location or relative position.

The position of the head varies decidedly and offers a good systematic character in certain subfamilies (Buckton, 1903:10). The variation ranges from an angle slightly greater than a right angle with the body, in certain Smiliinae, to an almost prone position in many of the Centrotinae (Plate xxx, 9–12). In no species does the head project straight forward on a line with the body, and in practically all species, no matter what the position of the head, the beak projects directly backward and lies between the coxae when at rest.

The *compound eyes* are large and prominent and are located at the extreme lateral margins of the head. In most cases the thorax is hollowed out to receive the eyes, and partly covers their upper and outer surfaces.

Two *ocelli* are present. These are located on the cephalic margin of the head, and their position with relation to each other and to the eyes is

apparently constant within a species. This offers in some subfamilies, particularly the Darninae (Amyot and Serville, 1843:545), a good specific character. The ocelli are always between the eyes and usually on a line with each other; but they may be near together close to the epicranial suture or far apart near the inner margins of the eyes (Plate xxx, 14–17).

The *antennae* (Plate xxx, 18) are located below and slightly in front of the eyes. These organs are very poorly developed, and studies in the biology of the insects seem to indicate that their function is extremely limited. Three basal segments are present, each more or less cylindrical, with the first segment the shortest. The filament is fine and hairlike and very minutely segmented. From seventy-five to eighty-two segments may be counted in the filaments of the species of the Smiliinae, and a slightly smaller number in the other subfamilies. These segments are longer at the base, closely compressed in the center, and longest at the extreme tip, of the filament. At the swollen base of the filament are a series of pits, from eight to twelve in number, situated on the inner curvature and giving rise to two or more bristle-like setae. In the material studied these structures were best seen in certain species of the tribe Telamoninae of the subfamily Smiliinae. In all cases the antennae were proportionally better developed in the nymphs than in the adults.

The general arrangements of the head sclerites are diagrammatically shown in Plate xxx, 19, and in Plate xxxi, 1 and 2. From the data obtained it would seem that these figures represent the most generalized type of the forms of the family.

The *occiput* consists of two sclerites more or less distinctly separated from each other, occupying the extreme hind part of the dorsal surface of the head and forming caudad the upper boundary of the occipital foramen. This region is covered by the overlapping flange of the anterior prothorax, which forms with it an articulating surface and is not visible unless the head is separated from the body. The lower ends of the occiput behind are fused with the postgenae below them and the suture is very indistinct in the adult head. In the nymph, however, the line of demarcation can usually be determined. Apparently these two regions — occiput and postgenae — are intimately connected in the membracid head and are probably closely related as to origin. The ordinary lower boundary of the sclerites appears to be the upper line of the eye, but in a few cases (Plate xxxi, 3) the suture has migrated to a point considerably below this line.

PLATE XXXI

1, Caudal view of head; 2, lateral view

3, Caudal view of head of *Enchenopa binotata* Say; 4, of *Tragopa tripartita* Fairmaire

5, Clypeus in *Telamona ampelopsidis* Harris; 6, in *Enchophyllum maculatum* Walker; 7, in *Campylenchia latipes* Say; 8, in *Centrodontus atlas* Goding; 9, in *Carynota mera* Say; 10, in *Enchenopa binotata* Say

11, Frontal outline of head of *Ceresa bubalus* Fabricius; 12, of *Ceresa taurina* Fitch; 13, of *Ceresa constans* Walker; 14, of *Ceresa Palmeri* Van Duzee; 15, of *Ceresa borealis* Fairmaire; 16, of *Stictocephala lutea* Walker; 17, of *Stictocephala diminuta* Van Duzee; 18, of *Stictocephala substriata* Walker; 19, of *Stictocephala inermis* Fabricius; 20, of *Stictocephala pacifica* Van Duzee

21, Vertex and clypeus of *Spongophorus guerini* Fairmaire; 22, of *Hypsophora insignis* Buckton; 23, of *Xiphistes furcicornis* Germar

24, Vestigial segment in head of *Ceresa taurina* Fitch; 25, in head of nymph of *Oxyrhachis tarandus* Fabricius; 26, in head of nymph of *Heranice miltoglypta* Fairmaire; 27, in head of *Membracis tectigera* Olivier

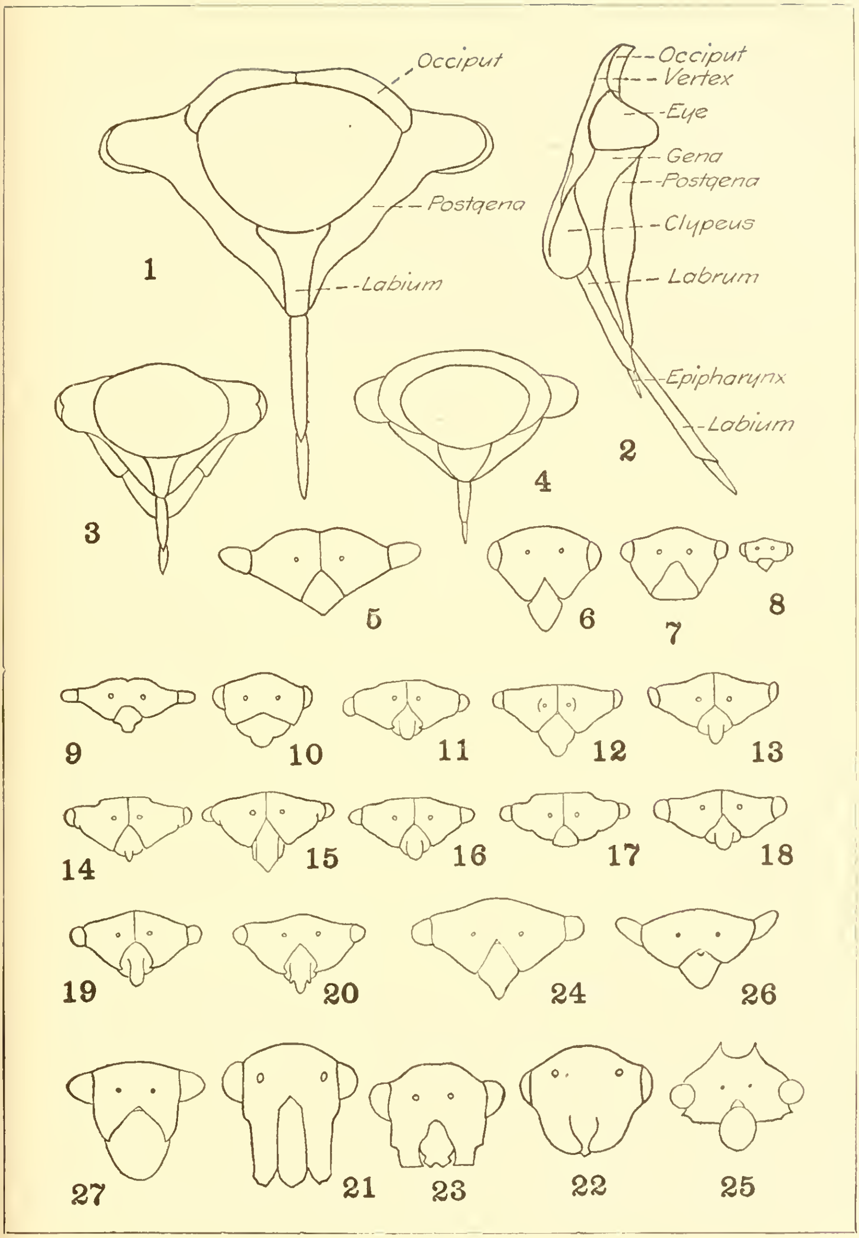
Occiput
Postgena
Labium
1
Occiput
Vertex
Eye
Gena
Postgena
Clypeus
Labrum
Epipharynx
Labium
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Plate XXXI

The *vertex* likewise consists of two sclerites, separated by the *epicranial suture*, and makes up the largest area of the cephalic part of the head. The sclerites are equal in size and are complements of each other in shape and position. The vertex occupies all that part of the head between the compound eyes, and between the occiput above and the clypeus and genae below. In each sclerite is located an ocellus. As has been noted, the relative position of the ocelli in the vertex is variable, the migrations of these organs being both sidewise and up and down. They are always, however, in a line with each other horizontally, and equidistant from the epicranial suture. In shape each sclerite of the vertex is roughly pentagonal, the basal, or dorsal, part often being sinuate to follow the anterior margin of the prothorax into which it fits snugly. On the whole the vertex shows considerable variation in form, and the lower cephalic edge is often infolded to form a sharp angle over the base of the antennae.

The *clypeus* is one of the most variable, most prominent, most interesting, and most important of the sclerites of the head. The position of this sclerite with reference to the vertex is, however, constant and no difficulty is experienced in locating it. The position of the clypeus as an unpaired sclerite between the arms of the epicranial suture suggests at once the possibility of confusing it with the frons. This indeed would be the natural conclusion, did not the location of the sclerite with reference to the arms of the tentorium of the endoskeleton preclude such a possibility. The anterior arms of the tentorium have been shown (Comstock and Kochi, 1902:39–42) to arise as invaginations at the cephalo-lateral angle of the clypeus or between the clypeus and the frons. In the case of the Membracidae these arms undoubtedly reach the cephalic margin of the sclerite in question, altho they have migrated slightly to the laterad. It would be impossible, therefore, to reconcile the conclusion that this sclerite represents the frons, with any of the previous work done on the subject, and it seems evident that it must be considered as the clypeus. In fact such a conclusion accords perfectly with the work done by Bentley (1900) on the cicada, in which he shows that the large projecting sclerite commonly known as the frons in that insect is in reality the clypeus.

In shape the clypeus is generally subquadrangular as seen from before, but projects backward at its extremity to form a deep, rounded keel (Plate xxxi, 2). This keel articulates with the gena on either side, and lifts the distal end of the clypeus up from the anterior outline of the head

to an extent which often leaves a sharp angle between the most cephalic part of the clypeus and the base of the labrum.

The variation in the shape of the clypeus and in the facial outline which it makes with the genae offers a systematic character of some importance. In general the character is generic (Distant, 1916:10) and apparently constant. The shape may vary from a broad, flat, almost perfect rectangle to a swollen rounded spindle or diamond, or, in some cases, nearly a circle (Plate xxxi, 5–10). It may continue with the genae an unbroken lower outline of the face, or may project far below the genae to form a long extension (Plate xxxi, 15, 24). This variation has been used as a specific character in certain American genera, particularly Ceresa and Stictocephala (Van Duzee, 1908a:42–43). Occasionally the outer margins of the clypeus are covered by the overlapping projections of the vertex (Plate xxxi, 21, 23); again, the vertex may be prolonged to a point below the clypeus. When such characters are present they have invariably been found good for systematic work. In fact the relation in position between the clypeus and the lateral margins of the vertex (the "cheeks" of the older writers) has been often noted as an excellent character in taxonomic tables.

The clypeus is much inclined to pubescence and the tip is usually decorated with stiff hairs or bristles which partly cover the base of the labium.

The *frons* is not represented as a distinct sclerite in the Membracidae. In certain forms, however, a vestigial segment which apparently represents this sclerite may occasionally be found between the vertex and the clypeus (Plate xxxi, 24–27). This has never been found as a constant, clean-cut, and well-marked sclerite, but numerous suggestions of its presence are offered, chiefly in nymphal material. Curiously enough the evidence is not limited to a single subfamily but is scattered thru widely separated genera. It seems reasonable to suppose that in the more primitive forms of insects the frons is present and bears the middle or the anterior ocellus. Comstock and Kochi (1902:14) state: "In the more generalized insects at least, if not in all, the front bears the median ocellus." Crawford (1914:5) notes, in connection with the psyllids:

> The *frons* has in most cases been overlooked in the Psyllidæ and the clypeus erroneously called the frons. In . . . . many . . . . genera the frons is scarcely visible as a sclerite, but in some species it is very prominent . . . . In all cases it is present as a small or large sclerite bearing the anterior ocellus at its base or the end nearest the vertex.

In the Membracidae two ocelli only are present. It would appear, therefore, that in this family the frons has disappeared, and with it the median ocellus which it contains. If, then, the triocellar condition is the more primitive form, the Membracidae in this respect are rather highly specialized.

The *labrum* is a single, heavily chitinized, subcylindrical piece attached to the distal end of the clypeus and projecting usually ventro-caudad from that sclerite (Plate xxxi, 1–4). Because of the inclined or prone position of the head, this piece is not visible except occasionally at its basal part from a strictly cephalic view of the insect (Plate xxxii, 1). Little variation is noticed in the labrum, but in the subfamily Hoplophorinae it tends to be shorter and stouter than in other membracids. Altho in the Membracidae the labrum should perhaps be considered as one of the head segments, not as an appendage (Comstock and Kochi, 1902:16), it is more or less movable in life and probably serves to support and guide the rostrum.

At the extremity of the labrum arises a small triangular piece, the *epipharynx* (Plate xxxi, 2). This sclerite is always distinct in both nymph and adult. In the former it appears as a soft, light-colored, fleshy extension of the labrum; in the latter as a stiff, hard, sharp segment distinctly set off at its base. In position it follows the general course of the labrum.

The *genae* form the lateral outline of the head and give the facial contour which is sometimes used in systematic diagnosis. Each gena is irregular in shape, being bounded dorsad by the vertex and mesad by the clypeus. Its lower extremity is contiguous with the base of the labrum. In general outline it is usually a long, rather flat plate, beginning at the lower margin of the eye and continuing to the rostrum. In the Smiliinae the ends are more or less pointed and the middle is swollen; in the Membracinae the entire sclerite is inclined to be nearly quadrangular. The genae are not set in the same plane as the frontal surface, but extend slightly caudad, so that the width of the sclerites determines in part the depth of the head.

Just behind the genae and forming the basal surface of the epicranium are the *postgenae*. These sclerites extend from the occiput to the labrum (Plate xxxi, 1, 2) and are most irregular in shape. The upper extremity

of each sclerite is projected laterad in a broad disk which almost entirely covers the hinder part of the eye. The inner edge bounds the occipital foramen and the lower end fuses with the lateral margin of the labrum. The extreme ventral projection follows the line of the labrum on the inner margin and the genae on the outer cephalic, and ends in an attenuated point.

The *occipital foramen,* as will be noted from the foregoing, is an almost circular opening, its edges lined with a thin connective-tissue membrane which is continuous with a like membrane from the inner body wall of the prothorax. This conjunctival membrane is of greater extent in the nymph than in the adult.

The *rostrum,* or beak, consists of a two-jointed labium containing the bristle-like maxillae and mandibles. It is stout and heavy, and is better developed in the nymph than in the adult. In the former it is rather fleshy and swollen, in the latter it is harder and more slender. The length of the rostrum has been used as a systematic character; but this character not only is of very doubtful value, but is hard to determine owing to the fact that the rostrum is carried flat against the ventral surface of the body. It may be hardly longer than the labrum or it may extend caudad beyond the hind coxae. This variation in length is, to be sure, great, but is not constant. Neither within the genus nor within the species has this character been found useful in systematic work.

The *labium* in the Membracidae does not differ essentially from that organ in other Homoptera. It consists of two segments, the basal segment being two or three times as long as the distal. The labium is grooved and bears within the groove the mandibular and the maxillary setae. The entire organ is movable, and when the insect is feeding it projects downward at right angles to the body. When not in use it is folded back between the coxae on the median ventral line of the body. In every form studied, the labium has been found to be straight, and no cases have been discovered in which the distal segment was bent forward as has been shown to be the case in certain other Hemiptera.

The *maxillae* are modified to form long, bristle-like setae. They originate from the interior surface of the vertex above the ocelli, at a point about midway between the ocelli and the margin of the occiput and slightly nearer than the ocelli to the epicranial suture (Plate XXXII, 3, 15). The

PLATE XXXII

1, Strictly cephalic view of head of *Enchenopa binotata* Say; 2, strictly ventral view; 15, caudal view, showing bases of maxillae and mandibles

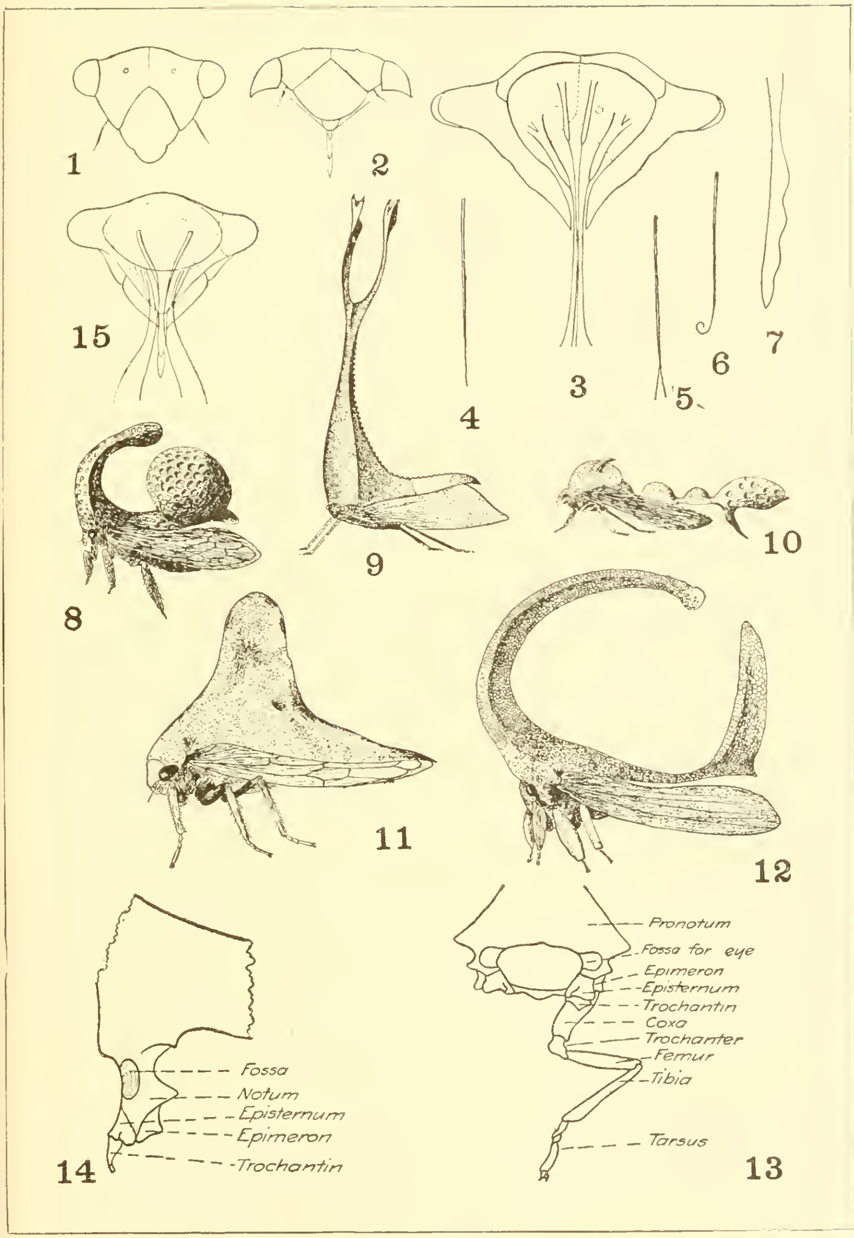
3, Caudal view of head, showing maxillae and mandibles

4, Maxilla of *Membracis mexicana* Guerin; 5, of *Thelia bimaculata* Fabricius; 6, of *Gargara pulchripennis* Stål

7, Tip of mandible, highly magnified

8, *Spongophorus inflatus* Fowler (after Fowler); 9, *Pyrgonata bifoliata* Westwood; 10, *Heteronotus trinodosus* Butler; 11, *Telamona alta* Funkhouser; 12, *Spongophorus ballista* Germar

13, Frontal view of parts of prothorax and leg; 14, lateral view of parts of prothorax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Pronotum
Fossa for eye
Epimeron
Episternum
Trochantin
Coxa
Trochanter
Femur
Tibia
Tarsus
Fossa
Notum
Episternum
Epimeron
Trochantin

PLATE XXXII

base of each maxilla is swollen to form a cylindrical club, which represents in length about one-third of that part of the maxilla inclosed in the head proper. The entire seta is uniformly cylindrical and smooth. It often extends for some length beyond the tip of the labium when extruded. The tip shows some variation, but in most forms it is gradually acuminate to a very sharp extremity. In one species of the genus Thelia (Plate XXXII, 5) the tips of the maxillae show a bifurcate condition, and in the genus Gargara (Plate XXXII, 6) they appear to be curled. It is doubtful, however, whether this is of anatomical significance.

The *mandibles* originate likewise from the vertex, but from a point latero-ventrad of the ocelli (Plate XXXII, 3). The base is broadly swollen and bicipital at its junction with the skeleton of the head. Like the maxilla, the mandible is extended in the form of a long, bristle-like seta; but, unlike the maxilla, this seta is not cylindrical but is flat and lance-like. The extremity is produced into a blade, which is smooth on the outer and sinuate on the inner edge (Plate XXXII, 7). In length the mandibles and the maxillae are about equal.

It will be noted that the attachment of the mandibular and the maxillary setae to the vertex does not agree with the conclusions reached in regard to other insects, in which these organs originate from the postgenae. In a large number of dissections of the membracids, however, this structure seemed to remain constant. Whether this condition represents a more or less specialized arrangement, or whether it is the result of migration of organs, can be determined only by investigations beyond the scope of this study.

The position of the base of the mandibles as described above has been found to vary only in a few of the species of one subfamily — the Membracinae. In this group it apparently arises from the upper part of the clypeus (Plate XXXII, 15). This may represent a still further migration, or a migration in a different direction from the generalized condition.

THE THORAX

Superficially the thorax presents the most striking and interesting part of the exoskeleton. This is of course due to the remarkable development of the pronotum, which is characteristic of the family. The promise

of peculiar scleritic structure thus suggested is not fulfilled, however, when the anatomy is studied. Aside from the unusual and oftentimes grotesque enlargement of the prothoracic tergum, the general arrangement of the skeletal parts is comparatively simple and rather easily determined.

The prothorax is very weakly attached to the mesothorax and separates from this segment easily. The mesothorax and the metathorax are firmly joined and the sclerites occasionally overlap in such a fashion as to strongly unite these last two segments.

On the whole the tergum of each thoracic segment is broad, smooth, and, with the exception of the pronotum, simple. The pleuron is narrow, irregular, and more or less complicated, the sclerites are inclined to be twisted from a normal position. The sternum is broad, much sculptured, and indistinctly sutured.

THE PROTHORAX

No evidence of cervical sclerites has been found. The only suggestion of such structures is a slight thickening of the connecting membrane in the gular region, which in certain species is of sufficient size to warrant attention. On the whole the membranous connection between head and prothorax is remarkably thin and easily ruptured, and shows nothing that could be considered as intersegmentalia or could represent the *microthorax* of Verhoeff (1902).

The notum of the prothorax shows so much variation thruout the family that no general discussion of it can be attempted. The peculiarities of this region represent by far the most striking and easily recognized characters of the Membracidae.

This part of the prothorax is usually expanded into a more or less irregular plate, which covers the entire meso- and metanotum, often the entire thorax, and in some cases the abdomen as well, and bears on its surface a wide variety of processes extending to form most grotesque and bizarre structures. A discussion of such variations would be merely an endless catalog, and is of course not to be attempted. Apparently the pronotal structures have no anatomical significance and are merely hollow extensions of the chitinized wall, raised high above the basal membrane which represents the normal body outline. An attempt to explain the function of this structure leads at once into the realm of

speculation. Poulton (1891 and 1903) has attempted to explain the meaning of a series of forms by mimicry and protective resemblance (fig. 39); Mann (1912) has noted a protective adaptation in a Brazilian membracid; and various authors have called attention to the resemblance of different species of Membracidae to parts of their hosts. No doubt the appearance of a large number of species may be explained by such theories; many more may be similarly accounted for by a liberal use of the imagination; by far a larger number, however, baffle the wildest flights of fancy. It is indeed hard to understand how it is possible for certain forms with wonderfully exaggerated pronotal processes to maintain their balance while flying. It is equally remarkable that these processes should not be at once broken off in the ordinary activities of the insect. Certainly it is hard to account for such developments by natural selection, and it seems more reasonable to regard the Membracidae as extreme examples of orthogenesis.

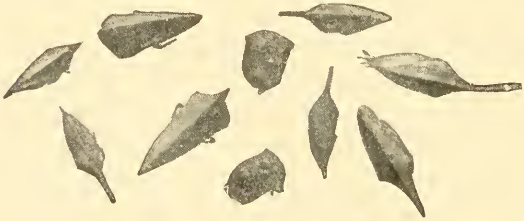


Fig. 39. FORMS OF MEMBRACIDAE SUPPOSED TO RESEMBLE SEEDS
(After Bastin)

Pronotal developments are, however, in spite of their questionable function, a boon to the writer of specific descriptions, and certain general structures in connection with such developments lend themselves well to generic diagnosis and are apparently constant. Some apply, at least as secondary characters, to each subfamily. It may be noted in this respect that the pronotum tends to develop in four principal directions — posteriorly, anteriorly, dorsally, and from the humeral angles (Plate XXXII, 8–12). These four great types of development may be found in various stages of enlargement thruout the family, and on them are based many attempts of subdivision into subfamilies, tribes, and genera. Modifications and combinations of these types are of course common, and in some species it is difficult to decide which type is dominant.

By far the commonest of these types is the development posteriorly, to cover the meso- and the metanotum and often the entire body of the insect. This posterior extension is found in so large a proportion of the forms that it appears to be a sort of foundation structure on which the

other types of development are built, and is apparently one of the most generalized of the prothoracic processes. It may vary from a perfectly simple short prong to a long, ornate projection often branched and extravagantly decorated with barbs, spines, bulbs, and ridges (fig. 40). So constant and so important is this posterior process that it has been made the character on which the subfamily Centrotinae is separated. All forms that have the posterior process wanting or so poorly developed that the scutellum is distinct — and it would seem that the development of the scutellum increases as that of the posterior process decreases — have been placed in this subfamily, which as a result has received a rather heterogeneous collection of genera (Fowler, 1894–97).

In generic and specific diagnoses the pronotal structures have been more generally used than any other characters shown in the family. This is to be expected, from the fact that they are prominent and quickly noted. Moreover, they are on the whole reliable and of much value. In the use of such characters, various areas and processes have received arbitrary names, which, while of little anatomical significance, are of assistance in making uniform the terminology used by systematic workers in the family. A few of these are deserving of special mention.

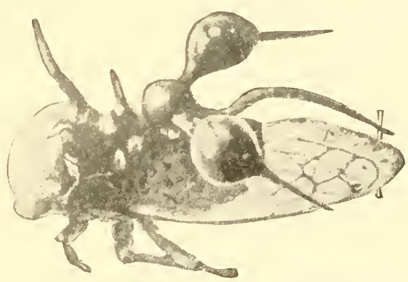


Fig. 40. Unusual development of posterior process
(After Bastin)

Metopidium (fig. 41, a) is a term originated by Fowler (1894–97:1) and commonly used by later authors (Van Duzee, 1908 a:30) to designate that area of the cephalic part of the pronotum reaching from the dorsum to the base of the head.

The *humeral angles* (fig. 41, b) are the swellings, very characteristic of the family, found on the lateral margins of the prothorax usually just above the bases of the forewings.

The *suprahumerals*, or *suprahumeral horns* (fig. 41, c), are the lateral projections on the edge of the metopidium just above the humeral angles.

The *posterior process* (fig. 41, d) is the posterior extension of the pronotum and is perhaps the most important and most commonly used character of all the prothoracic structures. Its size, shape, and develop-

ment, and especially its length as compared with abdomen and wings, have furnished valuable taxonomic data.

The *dorsal carina* (fig. 41, e), as the name would imply, is the median dorsal ridge which in many forms extends the entire length of the pronotum. Even when not percurrent this ridge makes a valuable character in description.

The terms *dorsal crest* and *dorsal spine* (fig. 41, f) are likewise self-explanatory and refer to the elevation of the type indicated arising from any part of the dorsum.

It would be impracticable to attempt to indicate the great number of ways in which each of these structures may vary. It would seem, however, from an examination of a large number of species and genera, that the posterior structures are inclined to be more constant than the anterior; the posterior process, for this reason, is found to be available as a generic character, while the more variable metopidium and suprahumerals are suitable for the separation of species.

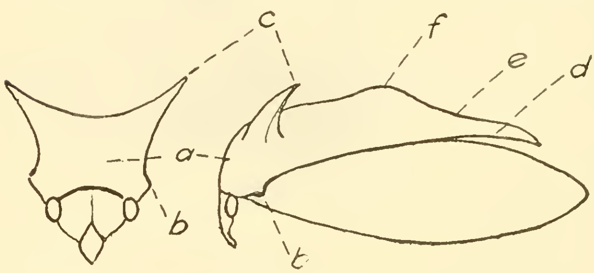


Fig. 41. FRONT AND LATERAL VIEWS OF TYPICAL MEMBRACID OUTLINE SHOWING PARTS OF PROTHORAX

The *pleuron* of the prothorax (Plate XXXII, 13) is joined directly to the notum without intervening sclerites. Two distinct lateral sclerites are found, the *episternum* and the *epimeron*. The notum projects downward between these sclerites in a triangular extension, the cephalic margin of which is hollowed out to form a fossa for the eye. Both episternum and epimeron are roughly triangular in shape as seen from a side view, the apex of the triangle pointing upward and the base forming part of the coxal cavity. Neither sclerite is subdivided but the episternum in some forms shows a slight indentation at the cephalo-ventral margin which suggests a coalescence. The *pleural suture* is not prominent, and is very short since the prolongation of the notum in this region forms a separating ridge which extends almost to the lateral margin of the segment. In certain foliaceous forms, as represented for example in many species of the Membracinae, this part of the lateral

notum is inclined to be more or less swollen or flattened and truncate at its distal extremity (Plate xxxii, 13). This is a dependable character, but is unnecessary for systematic diagnosis since other more easily distinguished characters are always present with it. In the rather remarkable genus Oxyrhachis the lateral margin of the pronotum is produced in an extended tooth, a character peculiar to the genus and important as a distinctive taxonomic structure. Just below the cephalad end of the episternum is found a triangular *trochantin*. This piece likewise is a single sclerite without evidence of subdivision.

The *sternum* of the prothorax consists of a single transverse bar extending between the coxal cavities (Plate xxxiii, 8). Dorsally this sclerite is smooth, and slightly curved to form the floor of the body cavity. The cephalic edge is also comparatively smooth and articulates with the posterior margin of the head. Ventrally the sternum is irregular in shape but in the simpler forms is trilobed, the central lobe projecting downward farther than the lobe on either side.

In summarizing the taxonomic importance of the sclerites of the prothorax, it may be observed that the pronotum, because of its variation in form, offers the most valuable characters, not only of the segment, but also, perhaps, of the entire body; the pleural sclerites are doubtless of enough importance to warrant careful study, but, because of the pubescence which is prevalent in this region in most species, they are not suited for superficial examination; the sternum is of practically no importance because of its small size, irregularity of structure, and inconspicuous position between the mouth parts.

THE MESOTHORAX

The mesothorax is intimately connected with the metathorax and its dorsal surface is usually completely hidden by the posterior process of the prothorax. The sclerites of the pleura, however, may be distinguished in the mature insect and their extent and position readily verified in prepared material.

The *notum* of the mesothorax shows two distinct types, according to whether the scutellum is or is not developed into a posterior prolongation. In by far the greater number of the species of Membracidae the scutellum is simple, rounded, and not at all extended posteriorly (Plate xxxiii, 3); in a smaller number it is prolonged into a strong prong or thorn, which

PLATE XXXIII

1, Lateral view of prothorax of *Enchenopa binotata* Say
2, Ventral view of prothorax
3, Mesonotum of *Telamona ampelopsidis* Harris; 4, of *Leptocentrus reponens* Walker
5, Mesopleuron in nymph; 6, in adult
7, Pleuron of mesothorax of *Enchenopa binotata* Say
8, Mesosternum
9, Ventral view of mesothorax; 10, dorsal view; 11, lateral view
12, Lateral view of metathorax
13, Prothorax and mesothorax of *Heteronotus nodosus* Germar, showing episternal hook
14, Metasternum

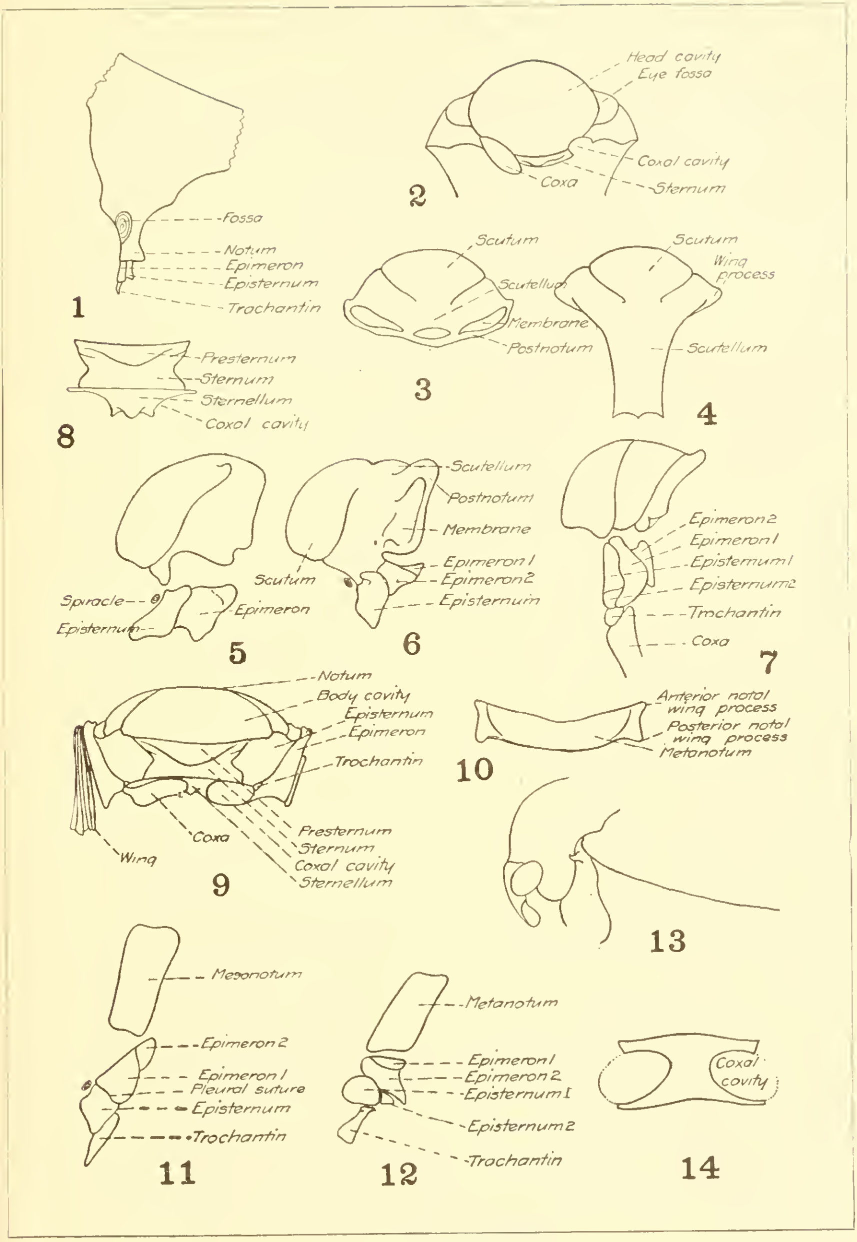


PLATE XXXIII

shows a wide range of shapes and positions (Plate xxxiii, 4). As has been noted, this difference has long served as a point of distinction between the subfamily Centrotinae and the other subfamilies. While this is a valuable and reliable character, it is unfortunate that it must be chosen as a primary distinctive structure of so large a group as a subfamily, since its determination often necessitates the destruction of the specimen.

The mesonotum usually shows three rather distinct areas, but these areas are apparently not separate sclerites since from the earliest nymphal forms they are evidently fused. In the adult, however, the regions are set off from one another by infoldings, or grooves, which may warrant the application of the usual names to these parts. The *scutum* is uniformly smooth, poorly developed, and weakly chitinized. Being covered by the pronotum it is not in reality an external sclerite at all and is not functional as far as protection is concerned. The *scutellum* when present forms the second region of the mesonotum, and, as has been noted often, develops to form a thick, heavy process; when undeveloped the scutellar region is indicated by a mere transverse fold. Both scutum and scutellum are often entirely membranous. Posterior to the scutellum is a third area, separated from the scutellum by a narrow band of connective tissue. This is probably homologous with the *pseudonotum* as described by Snodgrass (1909:522–523). Snodgrass has found (page 561 of reference cited) that in certain Hemiptera the mesopseudonotum is absent; but this judgment is based on the study of Heteroptera only, and the Membracidae are apparently representative of a different type of notal structure. In the more distinct forms this pseudonotum, or postnotum, is connected to the scutellum by one or more chitinized bridges (Plate xxxiii, 3), breaking the connecting membrane up into a series of lacunae. In two subfamilies, the Membracinae and the Darninae, an indication of a *postphragma* is found. This appears as an extra fold of the mesonotum, posterior to the pseudonotum, submembranous and irregular but of considerable size and fairly constant. Only one *wing process* is found, this being the posterior. The anterior process is barely indicated in a few forms by a thickening or doubling of the lateral margin of the scutum at its extreme ventro-caudal angle.

The *pleuron* of the mesothorax is more or less turned under the lateral margin of the notum, forming part of the ventral body wall. The position of the sclerites if they were spread out in one plane is diagrammatically

represented by Plate xxxiii, 5, 6. The *episternum* is a single irregular sclerite, closely fused with the lateral notum in the mature insect but separated by the anteriorly extended wing cavity in the nymph. The distal (ventral) extremity is produced into the sternal region. The caudo-ventral margin forms the upper edge of the mesocoxal cavity. In certain forms of the subfamily Membracinae the episternum seems to be divided by a transverse suture across its lower third (Plate xxxiii, 7). In this subfamily, also, the entire episternum is elevated so that it forms part of the articulatory surface of the wing. It will be noted that in the more usual arrangement (Plate xxxiii, 6) the episternum is crowded downward, and the produced notum serves as both the dorsal and the ventral margin of the wing cavity at its anterior end and only braces the wing at the posterior extremity of this cavity. Just cephalad of the episternum is a well-developed *spiracle* situated in the intersegmental membrane.

The *epimeron* consists of two distinct sclerites. The larger is roughly subquadrangular and joins the notum cephalo-dorsad and the episternum cephalo-ventrad. The second is a small triangular piece attached to the dorso-caudal margin of the first and no doubt originating as part of that sclerite. In the nymphal exoskeleton (Plate xxxiii, 5) the suture between these two sclerites is indicated but is not pronounced. The dorsal margins of the two epimeral sclerites form the larger part of the lower margin of the wing cavity, while the ventral margin of the anterior sclerite forms part of the dorso-caudal boundary of the coxal cavity.

In general it would appear that both the pleural sclerites of the mesothorax of the Membracidae tend toward subdivision. This would agree with the anepimeron and katepimeron and the anepisternum and katepisternum of Crampton (1909:21–24), but the homologies are not clear if that author's terminology limits the division to "upper" and "lower" regions.

No paraptera of any description have been found. A much-wrinkled connecting membrane at the anterior base of the wing may represent an episternal parapterum or preparapterum, but there seems to be no indication of epimeral paraptera or postparaptera. The basal wing membranes are not thickened and certainly not chitinized.

Directly ventrad of the episternum is a small but well-defined *trochantin.* This sclerite is roughly triangular in shape, with the base against the episternum and the apex extending cephalo-ventrad to form part of the ventral margin of the coxal cavity.

The *sternum* of the mesothorax indicates by its sculpture a development from three distinct sclerites, but even in the nymphal forms these sclerites are not clearly distinguished. For the sake of convenience in description the areas may be given the usual terms of *presternum, sternum,* and *sternellum,* altho it is not at all certain that the regions so designated are strictly homologous with the same sclerites in other insects. The entire sternum is roughly shield-shaped (Plate XXXIII, 8) and in the mature insect shows an anterior fold, a central plate, and a rather distinct posterior piece consisting of a thin arm partly encircling the coxal cavity on each side with a lobed central extension. The *presternum* is very indistinctly set off from the sternum, and indeed in very few cases can the faint lateral lines that are believed to represent sutures be determined. The sclerite can be distinguished, however, by the ventral lobe which is produced downward just behind the presternum. The central *sternum* is a flat, irregular plate fused with the presternum anteriorly and extending almost to the coxal cavities posteriorly. Its lateral margins unite with the ventral edges of the episterna. The *sternellum* is always more or less distinct. The lateral arms form the anterior edge of the coxal cavities and the central disk separates these cavities. The central disk bears in many forms a median protuberance, or tooth, which extends directly ventrad. The coxal cavities are not completely closed by the sternal plates of the mesothorax.

Because of the fact that the notum of this segment projects farther cephalad than the anterior line of the sternum, and because the pleural sclerites are turned under the overhanging edge of the lateral margin of the notum, a strictly ventral view of the mesothorax shows much more than the sternum (Plate XXXIII, 9). No other segment of the thorax is so well developed ventrally as the mesothorax, and no other shows any indication of subdivision in the sternum.

THE METATHORAX

The metathorax is a narrow segment closely fused with the mesothorax but weakly joined to the abdomen. In general structure it conforms to the preceding segment but none of the areas are so well developed.

The *notum,* as in the mesothorax, is an arched saddle-shaped sclerite forming the entire dorsal surface of the segment (Plate XXXIII, 10). No subdivisions have been found and the entire piece is relatively smooth.

The metanotum is more strongly chitinized than the mesonotum, probably due to the fact that this segment is less protected by the pronotum in most forms. The lateral extremities of the sclerite are slightly bent outward and bear two wing processes, an *anterior notal wing process* and a *posterior notal wing process*. Of these the anterior is the better developed.

The *pleuron* consists of an episternum and an epimeron, homologous with those of the mesothorax but differing in position with reference to the body axis. In the metathorax the sclerites appear to be twisted out of position, so that instead of being side by side, as in the normal condition, they are in an oblique line, with the episternum clearly below the epimeron and the pleural suture extending more or less ventro-caudad rather than perpendicularly (Plate xxxiii, 12). The pleural sclerites are distinctly set off from the metanotum by the wing cavity, the only connection being the interscleritic membrane.

The metathorax agrees with the mesothorax in showing no traces of paraptera. It would appear that one of the distinctive structural characters of the family is the absence of these supporting sclerites. How representative this condition may be of the entire group of Homoptera is not known, but a superficial examination of the exoskeleton of the cicada seems to show the presence of at least one postparapterum in that insect.

The *episternum* is subquadrangular and inclined to be prolonged at its ventral angle. In certain forms of the subfamily Membracinae a small sclerite, apparently derived from the episternum, is found just cephalad of this sclerite (Plate xxxiii, 12), but this has been noted in only a few species even of that subfamily. A divided episternum, however, would not be an unnatural condition, as evidenced by the structure of the mesothorax. The *epimeron* is distinctly divided into two sclerites, the larger being cephalo-ventrad of the smaller. Aside from a slight shifting in position thruout the subfamilies, the epimeron is a constant and uniform structure.

It may be mentioned that the pleura of both the meso- and the metathorax are much inclined to pubescence in the Membracidae. In certain genera of the Centrotinae this region is usually covered also with a hairy white excrescence, which in the adult insect completely hides all anatomical structures. These white tomentose patches are remarkably persistent and do not rub off easily. They have been used, in fact, and apparently

with success, as systematic characters (Distant, 1908 a:31), and are very distinctive in certain species. The nature and function of the deposit is unknown, but its presence in many forms entirely precludes the use of the scleritic structure for taxonomic purposes. This same woolly covering — described by various authors in various terms but often designated as "cretaceously sericeous" — is also commonly found on the exposed scutellum. In fresh specimens it is generally snow-white in color and is a most attractive decoration.

In the genus Oxyrhachis, previously mentioned, both the meso- and the metapleura are extended to form short, blunt teeth. Such developments are, however, rare in the family.

A striking development of the pleura which is characteristic of the Membracidae is found in the mesothoracic episternum. This is the *episternal hook* (Plate XXXIII, 13). This hook arises from near the upper anterior margin of the sclerite and projects forward, engaging the posterior margin of the pronotum. It is found in the great majority of the genera of the family, but not in all. Its function would appear to be the interlocking of the pro- and the mesothorax by an external mechanical means. It has been noted that internally these segments are but weakly joined, the intersegmental membrane being fragile and easily torn. The shape and the position of the hook vary but little, and in all cases the process is close to the wing base. It seems somewhat strange that this peculiar and rather conspicuous development should have escaped the notice of workers on the Membracidae, but there is apparently no mention of the structure in the systematic or the morphological literature of the family. The fact that it is absent in certain genera, but present in most, would seem to make it a valuable generic character. It has not been found to vary within a genus.

The *trochantin* of the metathorax is much larger than this sclerite in either of the other two thoracic segments. It shows the same general shape as in the other segments — an elongated wedge or triangle — but is longer, wider, and thicker. It forms part of the lateral margin of the coxal cavity and joins the cephalic bar of the sternum at its lateral extremity. No evidence has been found of either a transverse or a longitudinal divison of this sclerite, and nothing that would suggest the "trochantinus major" and the "trochantinus minor" which Crampton (1909:26–27) has found in other orders of insects.

In a very few instances small thickenings have been found in the coxal region, which suggest vestigial sclerites. So rare, however, have been such conditions that they cannot be said to be of importance in the family. In by far the larger number of forms the sclerites have been only of the number indicated, and no *accessory trochantinal* or *accessory coxal sclerites* (Snodgrass, 1909:541) are present. Neither does there appear to be any structure of a similar nature concealed by or hidden within the coxae, as has been shown to be the case in some hexapods (Crampton, 1909:32).

The metathoracic *spiracle* is located just cephalad of the upper angle of the episternum, in about the same relative position as that of the preceding segment. It will be seen that only two spiracles are found on each lateral of the thorax. Careful examination of the prothorax has been made for a like structure, with negative results. A prominent spiracle is located just caudad of the metathoracic pleuron and superficially appears to be a part of that segment; but, as will be noted later, this properly belongs to the first abdominal segment.

The *sternum* of the metathorax is much smaller than that of the mesothorax, and, altho its configuration suggests that it may be composed of two or more sclerites, absolutely no evidence has been found to bear out such an inference. Neither the nymphal nor the adult forms show sutures indicative of such development, and it seems necessary to discuss this part of the segment as a single sclerite. In shape the metasternum is roughly a transverse H (Plate xxxiii, 14), the openings at the ends of the figure representing the coxal cavities. The sclerite thus incloses the mesal curve and one-half of the cephalic and caudal margins of these cavities. The cephalic bar is slightly swollen ventrad, the middle connection is flat, and the caudal bar, again, is somewhat swollen.

As in the case of the preceding segment, a strictly ventral aspect of the metathorax shows more than the sternum (Plate xxxiv, 1). The lateral edge of the body is formed, not by a flat perpendicular pleural wall, but by the junction of the upper pleuron with the lateral ventral margin of the metanotum. The ventral view, therefore, shows the pleura as far dorsad as the wings.

Because of the intimate connection between the sclerites of the meso- and the metathorax, their relation to each other may perhaps be best shown by means of diagrammatic figures representing various views of these two segments together. Such an attempt has been made in Plate

PLATE XXXIV

1, Ventral view of metathorax; 2, dorsal view, 3, lateral view, of meso- and metathorax; 4, ventral view of entire thorax with legs removed

5–7, Theoretical wing positions

8, Base of fore wing; 9, episternum, showing groove; 10, axillary sclerites; 11, base of hind wing; 12, wing base of *Emphuses malleus* Walker, showing development of hooks

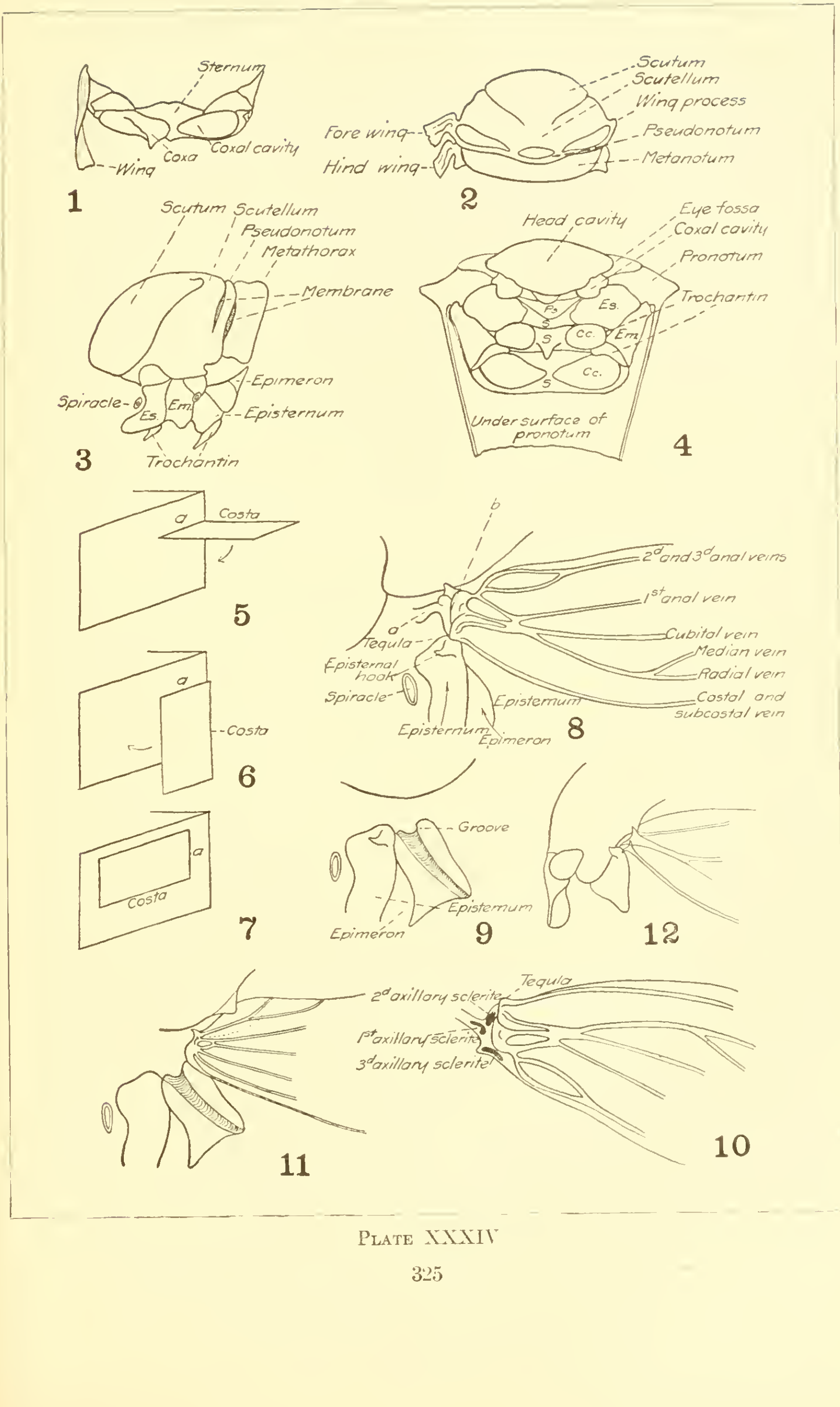

Sternum
Coxa
Coxal cavity
Wing
1
Scutum
Scutellum
Wing process
Fore wing
Pseudonotum
Hind wing
Metanotum
2
Scutum
Scutellum
Pseudonotum
Metathorax
Membrane
Epimeron
Spiracle
Es.
Em.
Episternum
Trochantin
3
Head cavity
Eye fossa
Coxal cavity
Pronotum
Trochantin
Es.
Cc.
Em.
Under surface of pronotum
4
Costa
a
5
a
Costa
6
a
Costa
7
b
2d and 3d anal veins
1st anal vein
a
Cubital vein
Tegula
Median vein
Episternal hook
Radial vein
Spiracle
Costal and subcostal vein
Episternum
Episternum
Epimeron
8
Groove
Episternum
Epimeron
9
12
Tegula
2d axillary sclerite
1st axillary sclerite
3d axillary sclerite
11
10

Plate XXXIV

xxxiv, 2, 3. These figures are intended to represent the more usual forms as shown in the family as a whole. It would of course be impracticable to endeavor to depict the large number of minor variations occurring thruout the genera, and no one species has been found which could be figured as a perfectly representative type.

In the same way a ventral view of the entire thorax is shown in Plate xxxiv, 4. When the prothorax is thus attached, the undersurface of the posterior prolongation of the pronotum will, of course, form the background of such a figure. This, to be sure, would vary remarkably in different species, but may be regarded as more or less typical for all subfamilies with the exception of the Centrotinae.

THE WINGS

The wings of the Membracidae have been discussed by the writer in a previous paper (Funkhouser, 1913), and need not be discussed in further detail here except to call attention to certain points in connection with their attachment.

It must be remembered that in the Homoptera the wings are folded against the body with the costal margin downward. This makes an apparent, but not a real, reverse of the normal position in insects. Theoretically the wing of an insect may be considered as in a plane projecting horizontally from the pleural wall of the body, with the costal region extending directly cephalad (Plate xxxiv, 5). Supported in such a position, the anterior part of the articulating surface of the wing is attached to the anterior wing process of the notum and the upper wing process of the episternum, while the posterior surface is attached to the posterior process of the notum and the wing process or the postparapterum of the epimeron. Actually, however, in most orders of insects the plane of the wing is more likely to be tilted upward, the costal region pointing slightly dorso-cephalad and articulating chiefly with the anterior notal process, while the anal region extends ventro-caudad and finds its chief connection at the pleural wing process between the episternum and the epimeron.

In the Membracidae, on the other hand, the costal margin of the wing appears on superficial examination to be attached to the upper extremity of the episternum — in fact it actually lies in a groove in this sclerite when at rest — while the anal area is clearly folded against the lower margin

of the notum. This position, which is not peculiar to the wings of the Membracidae but is found in most of the families of the Homoptera, causes a twisting and shifting of the parts of the wing base which requires special attention. If the theoretical position as above described is considered the normal, the position of the membracid wing may be conceived by imagining that the normal wing is first folded directly downward and then bent backward until its long axis is parallel with the longitudinal axis of the body. The movements necessary to accomplish such a change in position are diagrammatically represented in Plate XXXIV, 5–7. It is necessary to imagine that the horizontal plane representing the wing is attached at some one point, for example *a*, about which it is free to move. If then the distal end of the plane is moved downward until it is parallel with the body wall, it will illustrate the first movement required. This movement is not an unnatural one, since it represents a part of the normal movement of the wing in flying. In order to reach the position desired, however, the plane, still remaining flat against the body wall, must be swung upward thru an arc of ninety degrees so that the long axis of the plane is parallel to the long axis of the supporting wall. The plane is now in the position assumed by the membracid wing.

In order, however, to appreciate the mechanical changes that the wing base has undergone, it is necessary to conceive of two points of attachment instead of one, these points representing the anterior and posterior angles of the articulating surface. It will be seen that the anterior point will be pulled downward and backward, while the posterior point will be moved upward and forward.

This is apparently what has occurred in the wings of the Membracidae, and it will be understood at once that such a migration of basal structures renders difficult the homologizing of parts. In spite of the twisting, however, it is possible to reconcile to a large extent the shifted attachments as shown in this family with the commoner interpretation of the wing base in other insects. It has been noted, in the discussion of the pleural and the tergal sclerites, that in the Membracidae no anterior notal wing process could be determined, while the posterior process was prominent. This is probably explained by the fact that the anterior angle of the wing base has migrated away from its normal position, making the anterior process unnecessary; while the posterior angle has moved upward, increasing the musculature of the posterior region.

The position of the fore wing is shown in Plate XXXIV, 8. The principal point of attachment is a long, curved, partly chitinized cord, fused along the costal and the middle part of the wing base (the cephalo-ventral margin when in the normal position) and extending between the notum and the episternum into the body cavity, where it is connected with the wing muscles. This cord supports and probably directs the movement of that part of the wing which accommodates the bases of the costal, subcostal, radial, median, and cubital veins. It is rather sharply set off, however, from the tissue of the wing proper by a deep constriction. When the wing is separated from the body it usually breaks along this line. The extreme cephalic costal angle is supported by the dorsal margin of the mesothoracic episternum. When at rest and folded against the body, the basal fifth or sixth of the costal margin is supported by the metathoracic episternum, which is hollowed out to receive it. This deep groove in the episternum of the following segment (Plate XXXIV, 9) is indeed very characteristic of the family.

Results from the study of chitinized parts of the wing base are most unsatisfactory. The tissue of this region, when treated in the usual manner in caustic potash, is generally completely broken down and shows no evidence of impregnation. It is doubtful whether any true sclerites are present, but occasionally slight thickenings of irregular shape are noted which may represent such structures. When visible, these are indefinite in outline, but they may be represented by the shaded areas in Plate XXXIV, 10. They are here tentatively indicated as the first, second, and third axillary sclerites, but their homologies may well be questioned. In fact, histological studies would seem to indicate that the entire region is normally composed of muscular and connective tissue. No evidence of the fourth axillary sclerite has been found. This, however, is not surprising, since it has been shown that this sclerite is present only in a limited number of insect orders (Snodgrass, 1909:543). The cephalic costal angle is swollen into a protuberance, or tooth, which is probably homologous with the *tegula* of other insects. It is usually pubescent, if not actually hairy, but is not chitinized. The basal region of the fore wing is much given to the development of barbs, or hooks, which in some cases interlock with one another or with the notum and in some cases are isolated and seem to have no supporting or bracing function (Plate XXXIV, 12). These hooks have never been used as taxonomic characters, but there

seems to be no reason why they should not be so used since they are apparently constant within a species and differ in appearance within a genus. The basal and costal areas of the wing are inclined, also, to be coriaceous, punctured, pubescent, or opaque. These features are commonly used as specific characters, and in some cases (Van Duzee, 1908 a: 55) as generic. In one subfamily, the Tragopinae, the fore wings are so dense and coriaceous that the veins are scarcely distinguishable. This character, indeed, is generally given as distinctive for this subfamily.

The hind wing (Plate xxxiv, 11) is similar to the fore wing in position and attachment. It rests partly on the dorso-caudal extremity of the metathoracic episternum, and is attached by strong muscles which extend into the body cavity just below the metanotum. The anal lobe is folded under the remainder of the anal area when the insect is at rest, as indicated by the dotted lines in the figure. At the base of the anal region is a strong hook, which is generally constant in appearance but the function of which is not evident. The caudal margin of the metanotum shows in some species an overhanging flap which engages the wing when folded.

No axillary sclerites have been found in the hind wing. From this fact it might be well to question the correctness of the interpretation of the structures described in the fore wing as axillaries. There is little doubt that the hind wing in the Membracidae is more generalized than the fore wing, and one would naturally expect to find in the more generalized wing the better evidence of primitive structures. The fact that such structures cannot be found would indicate either that the axillaries are not primitive in the family or that the thickenings in the fore wing are not true axillaries. The latter theory is perfectly tenable, since, as has been remarked in the discussion of these structures, their validity as chitinized sclerites may well be doubted. It is true that the full complement of axillaries has been recorded for other Hemiptera (Snodgrass, 1909: 594), but here again the forms studied belong to the Heteroptera. A study of the alary and the pedal apparatus would seem to indicate that the relationship between the Heteroptera and the Homoptera may not be so close in respect to locomotion as in other respects, and the presence of the sclerites in the former suborder need not necessarily presuppose their existence in the latter. In fact one or two orders, notably the Ephemerida and the Odonata, have thus far failed to show axillary sclerites and it would appear that the Homoptera might be grouped with these orders in this

respect. It has already been noted that paraptera were lacking in the Membracidae, and if the axillary sclerites are also missing the wing base as a whole must be considered as being very poorly developed.

Aside from the basal region the wings of the Membracidae are usually membranous. It has been noted that in the small subfamily Tragopinae this is not the case, but this subfamily consists of only three genera containing a very limited number of species. In general the wing consists of a distinct corium and clavus, the claval suture occurring along the first anal vein. Both pairs of wings are well developed and expanded. Both are characterized by having a strongly scalloped margin outlined by the ends of the veins, and in most forms a distinct terminal membrane beyond this margin. The extent of this marginal membrane is considered a good taxonomic character and has been used in generic diagnosis (Amyot and Serville, 1843:533). The wings may be entirely, partly, or not at all concealed by the pronotum. This variation also has proved of value to systematists, and on it are based many keys and tables to genera and tribes.

Other general characters of the wings that are used in taxonomic work are the length as compared with each other, with the abdomen, and with the posterior process, the shape of the extremities, the colors and markings, and the venation. A discussion of the last-named character is here omitted, since it forms the subject of a previous paper by the writer. It may be stated, however, that for systematic purposes the wing veins yield many valuable characters. This is especially true of the hind wings, which are by far the more constant and apparently the more generalized. Unfortunately the hind wings are always covered by the fore wings and are usually much shorter than the fore wings, so that their examination necessitates the relaxing of the specimen. Moreover, in many cases both wings are entirely hidden under the pronotum. A more or less superficial character of the wing veins, but one which is believed to be of value at least for specific distinction, is the presence of punctures along their courses. In some species each vein is bordered by a double row of such punctures and often by corresponding rows of bristles.

THE LEGS

The legs in the Membracidae show some interesting features structurally and are of importance taxonomically. All three pairs of legs are

normal in such general points as the number, position, and relative size of the segments, and the attachment to the torso. The individual segments, however, are much inclined to variation thruout the family. The simplest type of leg is found in the subfamily Smiliinae, in which there are but few differences in leg structure in the various genera (Plate xxxv, 1–5). The legs increase in length from before backward in practically all the genera, but in a few the first and second pairs are about equal in length. The hind legs are always the longest. It is possible that the relative leg lengths may be of value in systematic diagnosis, but the character would be a very hard one to determine in ordinary mounted material because of the fact that the legs are so often tightly folded against the lower part of the body. In life the front legs usually point forward and the second and third pairs backward. The front legs, in fact, are attached so closely to the head as to completely hide the mouth parts and the gular regions when the insect is at rest in its natural position. All the legs, and particularly the posterior pair, are very well developed, as would be expected from the jumping habits of the insects. The basal parts are heavy and swollen and cover most of the ventral surface of the thorax. The legs are much inclined to pubescence and often bear spines. Particular development of such structures will be discussed under the separate segments.

The *coxae* are heavy and stout. The posterior pair are usually the largest and closest together, and show the greatest tendency toward peculiar development. Each coxa consists of a flattened plate which fills up the coxal cavity, and a distal projection to which the trochanter is articulated. This distal projection is often bent at an angle to the other two-thirds of the segment and projects ventrad. Between the body of the coxa and its distal end is found in some cases a constriction, or neck (Plate xxxv, 6–9). The articulatory surface is generally swollen and often apparently distorted. In a large number of species the lateral end of the middle and the hind coxae is distinctly cut off, leaving a triangular piece laterad of the body of the segment but in the coxal cavity. In the adult this is represented by a deep suture (Plate xxxv, 1–2), and boiling in caustic potash shows that this is really a division between the chitinized areas. This separate piece is believed to be a subdivision of the coxa and originally a part of that sclerite. A comparative examination of the cicada shows the segment still more distinct and differently located in that insect

PLATE XXXV

1, Cephalic view of left front leg; 2, cephalic view, 3, caudal view, of left second leg; 4, cephalic view, 5, caudal view, of left hind leg

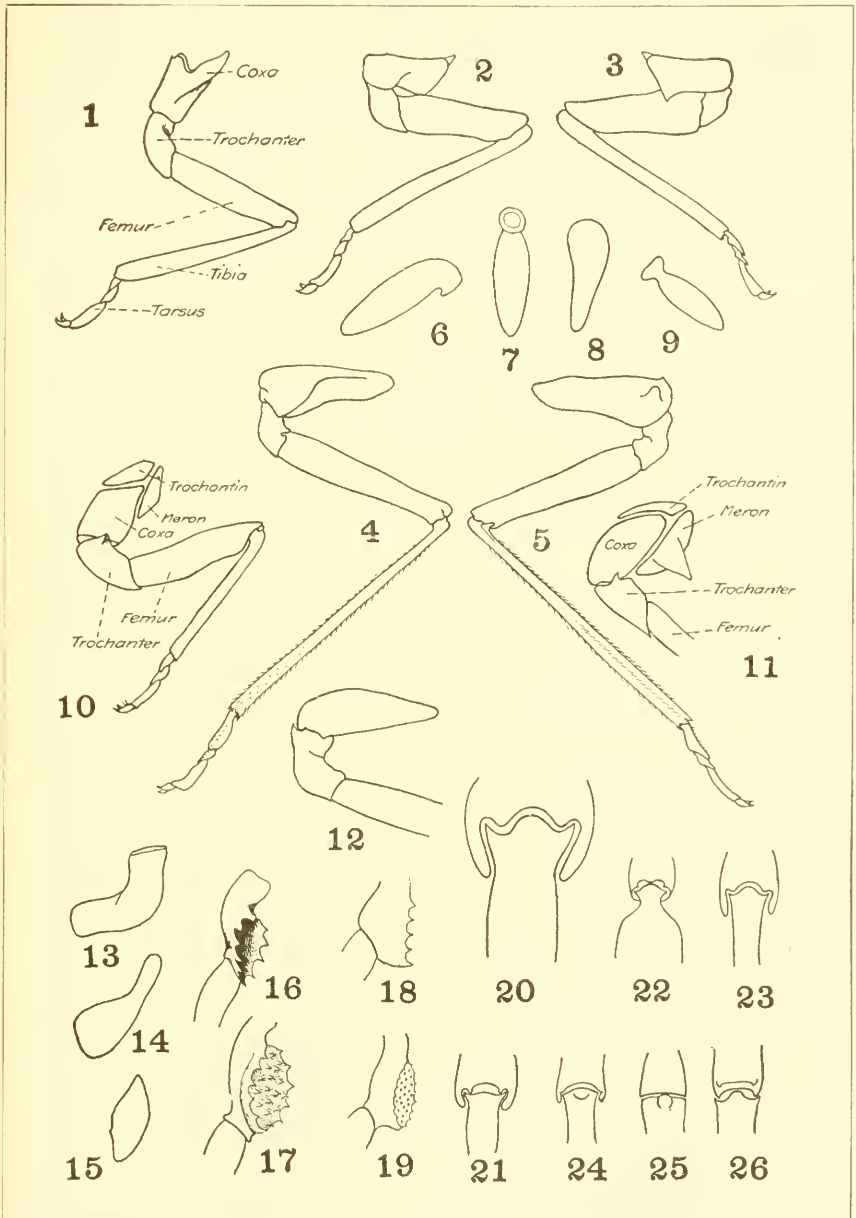
6–9, Types of coxae

10, Basal regions in middle leg of cicada; 11, in hind leg

12, Trochanter, showing hooks at coxal joint; 13, trochanter of *Thelia bimaculata* Fabricius; 14, of *Tricentrus fairmairei* Stål; 15, of *Enchenopa binotata* Say; 16, of *Centrotoscelus typus* Funkhouser; 17, of *Sipylus nodipennis* Funkhouser; 18, of *Tricentrus pilinervosus* Funkhouser; 19, of *Tricentrus capreolus* Walker

20, Knee joint

21, Femur-tibia joint in genus Carynota; 22, in genus Membracis; 23, in genus Leptocentrus; 24, in genus Tricentrus; 25, in genus Xiphistes; 26, in genus Heteronotus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Trochanter
Femur
Tibia
Tarsus
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3
6
7
8
9
4
5
Trochontin
Meron
Coxa
Femur
Trochanter
10
Trochantin
Meron
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Trochanter
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PLATE XXXV

(Plate xxxv, 10, 11). This would suggest that perhaps the piece is a true *meron*, and indeed it might be considered as such in the cicada. In the cicada this meron of the posterior leg shows a strong spine and the entire piece is much enlarged. The coxa in the Membracidae also shows spines or protuberances in many species (Plate xxxv, 5), and the question arises as to whether these might be homologous with the meral spines of the cicada; but this interpretation would hardly be reasonable because of the fact that the spines are chiefly on the interior rather than the lateral margins and are never set off by sutures. In fact these spines, or teeth, are rather irregular in position and show much variation. In no case has any evidence been found that they are indicative of separate sclerites. The coxa has not been used for systematic work in the Membracidae, and it is doubtful whether it is of value for this purpose. Such distinctive structures as may be present, as spines or elbows, are usually on the mesal angles rather than on the ventral or the lateral angles, where they might be easily identified, and are, moreover, not at all constant in the forms that have been studied.

The *trochanter* is normally an elbow-shaped segment attached to the ventro-mesal extremity of the coxa (Plate xxxv, 12–15). The proximal half projects directly ventrad, while the distal half turns ventro-mesad. The segment is freely movable in the Membracidae, and the articulation with the coxa is comparatively weak. The coxa-trochanter joint, however, is often strengthened by the overlapping hooks or projections, which tend to overcome this weakness (Plate xxxv, 12). No special modifications are found in the trochanters of the first or the second pair of legs, but in those of the hind legs most interesting developments may be found. The commonest variation is that of general shape. In most species the segment is practically cylindrical, bent in the middle but nearly equal in diameter at each end (Plate xxxv, 13). This shape graduates to a roughly spatulate outline (Plate xxxv, 14), in which the proximal end is much narrowed and nearly cylindrical while the distal end is broadly flattened and paddle-like. In certain species of the subfamily Membracinae the segment is shortened and nearly straight, the internal angle being hardly recognizable and the articulatory surfaces almost in a line with each other (Plate xxxv, 15), giving the entire segment a spindle-shaped outline.

By far the most interesting modification of the trochanter, however, and one that is extremely valuable for systematic purposes, is the develop-

ment of teeth on the internal surface of the distal half (Plate xxxv, 16–19). When teeth are present the distal end is expanded into a flat plate, or disk. In the simplest form the teeth are arranged around the edge of this disk (Plate xxxv, 16) and the disk is often hollowed out in the center. The commoner type, however, is the arrangement of the teeth over the surface of the disk (Plate xxxv, 17), with those on the margin slightly larger than the others. The disk is often elevated to a considerable distance above the body of the trochanter, and its surface between the spines is usually pebbled or thrown up into slight nodules. From a strictly lateral view the edge of the trochanter appears merely dentate (Plate xxxv, 18), and the opposite edges of the same disk are not uniform in number or position of the teeth. In some species the teeth are very small, and cone-shaped (Plate xxxv, 19), and in almost all cases they are jet-black in color.

An interesting feature in connection with the presence of the teeth is the shifting of the attachment of the femur. Ordinarily the femur is attached to the lateral end of the trochanter and extends more or less laterally from the body. When the teeth are present, the plate, or disk, that bears them is developed from the region at which the femur ordinarily articulates. This forces the base of the femur around to the mesal rather than the lateral angle, and the femur is thus forced to point farther inward or else develop a curve in its proximal end. The faces of the toothed disks of the two trochanters oppose each other when the legs are in the normal position, and if the legs are brought close together the teeth meet and interlock.

No explanation has ever been offered as to the function of these teeth, and their utility is questionable. They occur on both sexes and are very constant. The nymphs show no suggestion of the structures in the specimens that have been examined, but the material seen has been extremely limited since most of the species that show the modification are African and Asiatic and the immature forms are hard to obtain. So far as the biology of these species is known, their life histories differ in no respect from those of other forms that lack such structures.

Another character that is apparently closely related to the toothed condition is found in the hairs, or bristles, which often occur on the internal face of the trochanter in many species. The fact that these bristles are borne on the same area which gives rise to the teeth in the armed

forms, and that the genera in which the bristles are found are closely related to those that bear teeth, would suggest that the two forms of modification may be the response to similar orthogenetic tendencies.

The spined trochanters were first used in systematic work by Stål (1866:89), as a character for the separation of his genera Tricentrus and Sipylus. They have since been used as the primary character for the genus Centrotoscelus (Funkhouser, 1914a:73). There can be little question as to their importance in characterizing these three genera. Distant (1908a:53), while admitting the value of the "armed trochanters" on which Stål so largely relied, raises an objection to their use as taxonomic characters on the ground that they are difficult to distinguish. This is hardly a valid criticism because of the fact that only the posterior pair need be observed and these are plainly visible from a caudal view. Moreover it is merely the presence or the absence of the spines, not their anatomical minutiae, which is required for diagnosis.

The *femora* show the least variation of any of the leg segments in the Membracidae. In shape the femur is usually club-like and often much curved. The proximal end is swollen, and the segment gradually narrows toward the distal end. The distal end is in some cases suddenly expanded to form a knob, or head, and before this is a slight constriction, or neck. The entire segment is subcylindrical, seldom flattened, and never angular. It is the largest and strongest segment of the leg and doubtless furnishes the chief power in jumping. The distal end is hollowed out to receive the end of the tibia, and usually projects slightly on either side into a plate to direct and strengthen the knee joint. The femur is much inclined to pubescence, but in this respect it follows the general tendency of the leg as a whole and does not differ from the other segments. It seldom possesses a color pattern, even in gaudily decorated species.

The *knee joint*, or joint between the femur and the tibia, offers an excellent illustration of adaptation of structure to habit and is mechanically interesting. The femur above is hollowed out on the dorsal margin of the joint to form a fossa for the reception of the head of the tibia. Laterad of this fossa occur smaller indentations to receive the lateral teeth with which the head of the tibia is usually equipped. Ventrolaterad of these indentations the lateral margins of the femoral head are expanded to form projecting plates which hold the proximal end of the tibia in place. The general structure is shown diagrammatically in

Plate xxxv, 20. The median lobe at the head of the tibia is smooth and polished and more or less spherical. Occasionally it is strikingly different in color from the remainder of the leg and stands out in sharp contrast; in a few species these rounded heads are snow-white and glisten like shining pearls, in others they are brilliant orange or red and very conspicuous. They are not, however, very constant even within a species, and therefore are not suitable for taxonomic characters.

The general structure of the joint, on the other hand, shows some interesting variations which appear to be constant enough to warrant more careful attention from the standpoint of systematic work. In a large number of forms studied, the structure proved to be distinct enough between species, and occasionally between genera, to be of real assistance in this respect, and, altho this structure has never been used in published diagnoses, it is believed to be of value. A few of the types of variations are figured in Plate xxxv, 21–26, these being chosen at random from common genera. It may at first thought seem extravagant to attempt to find in leg joints characters for taxonomic use. It must be remembered, however, that the Membracidae are primarily a jumping family, and the legs are used to a far greater extent than the wings. It would not be surprising, then, to find modifications in leg structure comparable to changes in wing structure in other insects, and, while it is not to be supposed that such modifications are of great phylogenetic importance, they may still be of enough value to warrant their careful consideration. Moreover they are well adapted for study, since the leg usually projects outward and brings the knee joint into a position which facilitates examination.

The *tibia* has attracted more attention in the Membracidae than any other segment of the leg. This is because in certain forms of the family this segment is broadly foliaceous and very striking in appearance. On the basis of this peculiarity the genus Membracis, the type genus of the family, was early separated (Fabricius, 1775:675), and the character has since stood as the distinguishing mark of the subfamily Membracinae which has been built up around this genus. This character in itself, however, is not sufficient to distinguish the subfamily, since a number of genera of the subfamily Centrotinae show the same flattened, leaf-like tibiae. It is valid only when considered in connection with the covered scutellum.

The foliaceous tibia as represented in the type genus (Plate XXXVI, 1–3) shows a decided variation in the three pairs of legs. In the first and second pairs the tibiae are broadly foliaceous, often three times as wide as the femur, and generally smooth and without spines or bristles. In the posterior pair of legs the tibiae are proportionately much narrower and less leaf-like, and are usually armed with strong teeth, or spines.

The fore tibia is the broadest in proportion to its length (Plate XXXVI, 1). The proximal end is lobed to conform to the configuration of the distal end of the femur. The anterior margin of the segment is suddenly swollen to form a wide lobe at about the middle. The posterior margin is less convex and rather regularly curved. The distal end is slightly notched in the middle to receive the first joint of the tarsus, which appears remarkably attenuated as compared with the broad tibia above. Buckton (1903:26) has described and figured a gland on the front tibia of *Membracis mexicana* Guer. This gland he represents as a disk-like, punctate organ, occupying nearly half the diameter of the distal extremity of the segment. A careful study of a series of specimens, both male and female, of this species fails to show the slightest evidence of such a structure, nor has any development approximating such a gland been found in any other species of the genus or in the family. Apparently no other workers in the Membracidae have noted such a modification of the tibia, and it would be interesting to know the exact data on which Buckton based his description.

The second tibia is longer than the first and proportionately not so broad. As in the fore leg, the anterior margin is more curved than the posterior, and the extremities are modified in a similar manner.

The hind tibia is longer, narrower, and less foliaceous than the first and the second. It is usually margined by teeth on both the anterior and the posterior edge, and smooth on the lateral and the mesal surface. Each segment is inclined to be hollowed out on the lateral surface and convex on the mesal (Plate XXXVI, 10–12), so that in cross section the segment is more or less curved. The fore tibia is more nearly uniform in thickness (Plate XXXVI, 10), the middle tibia is thickened toward the anterior margin (Plate XXXVI, 11); and the hind tibia is much swollen anteriorly to produce a heavy ridge (Plate XXXVI, 12). The hind tibia is often channeled or grooved along the anterior margin, giving a somewhat triquetrous appearance to the whole segment.

This description applies pretty generally to the tibiae of all the species in the subfamily Membracinae, and very few generic or specific structural characters have been noted. The legs are usually so placed when the insect is at rest in a natural position that the broad, flat, lateral faces of the tibiae completely hide all other parts of the legs and most of the ventral thorax. From a cephalic view (Plate XXXVI, 4–6) the tibiae appear less flattened, and in those that are spined only one row of spines is seen.

It has already been noted that foliaceous tibiae occur in species widely removed from the Membracinae. These are commonest in certain genera of the subfamily Centrotinae. In this group the tibiae are often even more leaflike than in the type genus described above, and more striking in appearance. One noticeable difference, however, is the fact that in the Centrotinae all three pairs of tibiae are foliaceous (Plate XXXVI, 7–9), and the hind pair are often as broad as either of the two preceding pairs. In these forms the hind tibia is seldom spurred, but all three pairs are inclined to develop short, stiff hairs along the margins. In cross section also a difference is noted (Plate XXXVI, 13–15), in that the segments seem to be developed from a central rod with the margins appearing as lateral expansions. This condition is most noticeable in the posterior tibia, in which the central rod has a decided midrib appearance (Plate XXXVI, 15). These characters are quite sufficient to distinguish most of the species of the Centrotinae which show the foliaceous type of leg.

In by far the larger number of forms of the family the tibia is round, oval, or triangular in cross section (Plate XXXVI, 16–18) and uniform in diameter (Plate XXXV, 1–5). In the non-foliaceous type of tibia the first and second pairs are most likely to be rounded while the posterior pair usually shows the three-cornered shape. In the latter form one angle points directly cephalad while the other two angles project latero-caudad to the right and left, leaving a flat posterior face. All three angles bear spines or hairs. It should be remembered in interpreting these terms that in the normal position the hind leg of the insect projects almost directly backward from the body, the coxa extending more or less meso-laterad, the trochanter latero-ventrad, the femur dorso-caudad, and the tibia ventro-caudad.

The tibiae show color patterns and various markings when the legs are at all decorated. These segments also are usually pubescent, or hairy, and the extremities generally show one or more rings of spines or bristles

PLATE XXXVI

1–3, Legs of *Membracis foliata* Linné; 4–6, of *Enchenopa binotata* Say; 7–9, tibiae of *Oxyrhachis tarandus* Fabricius

10–12, Cross sections of tibiae of *Membracis foliata* Linné; 13–15, of *Oxyrhachis tarandus* Fabricius; 16–18, of a non-foliaceous type

19, Left hind tarsus, showing spines

20–22, Lateral views of tarsi of *Ceresa bubalus* Fabricius; 23, dorsal, 24, ventral, and 25, lateral, views of hind tarsus; 26, lateral view of claw; 27, fore, 28, middle, and 29, hind, tarsi of *Platycotis sagittata* Germar

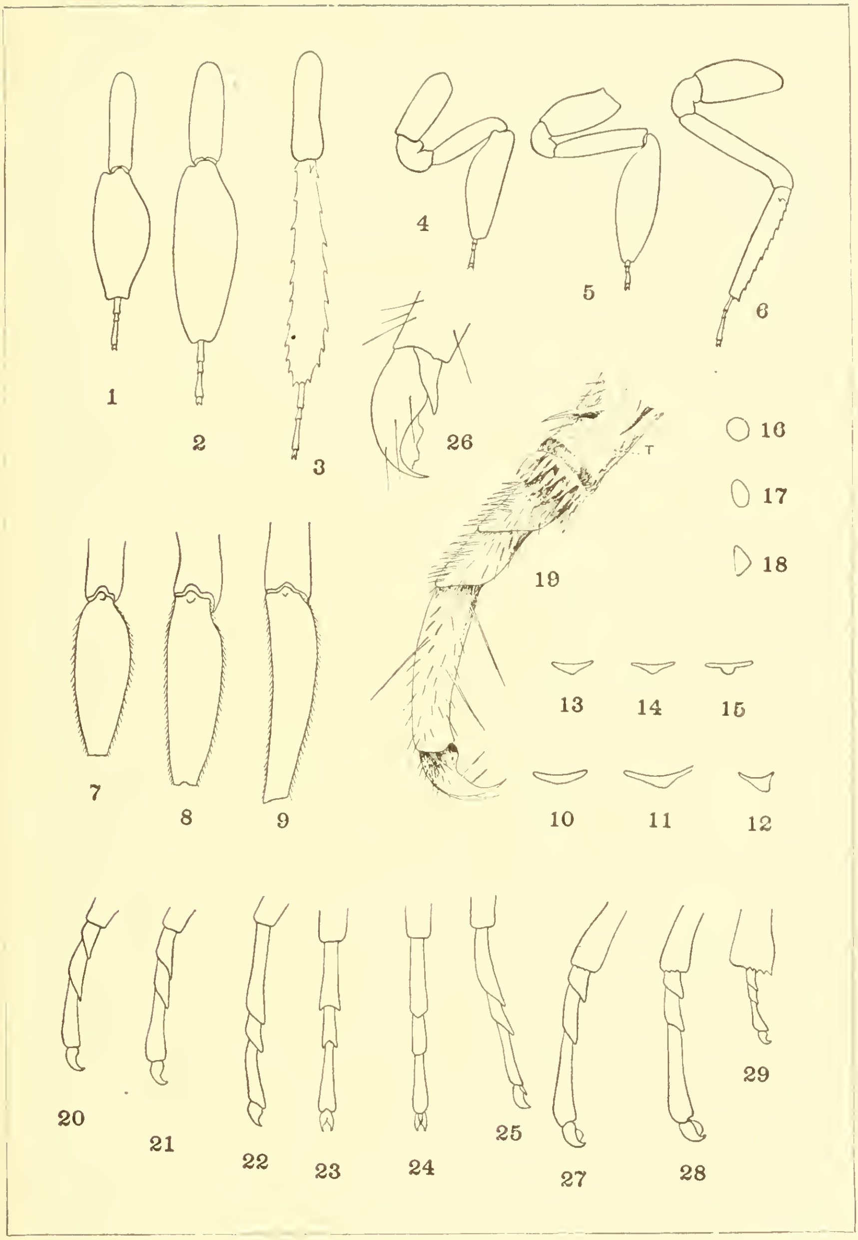
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Plate XXXVI

encircling the base of the first tarsal segment (Plate XXXVI, 19). Such developments are common on the tibiae of all three pairs of legs but are best shown on the posterior pair. The nymphs often show markings and ground colors on the tibiae which do not appear on the adult insect. Such colors are lost in the last molt, and, while of no importance in the general study of the body segments of the adult, have been found of value in recognizing the immature forms.

The *tarsus* is trimerous and comparatively uniform thruout the family. Of the three segments the middle one is usually the shortest (Plate XXXVI, 20–22); the first and the last vary with the leg, the first being the longest in the hind leg and the last being the longest in the first two pairs of legs. Each segment is somewhat club-shaped, narrower at its proximal and swollen at its distal end. At the distal ends the segments are not evenly truncate but are much extended on the underside and bilobed above (Plate XXXVI, 23–25). In some species this bilobed condition is much exaggerated, as in *Hebeticoides acutus* (Fowler, 1894–97, tab. IV, fig. 17 c).

Each tarsus bears a strong *claw*, distinctly articulated with the last segment (Plate XXXVI, 26). Each claw is heavy at its base and becomes gradually acuminate to a fine, sharp point. No pulvillus is present, but most forms show a broad, irregular membrane below each half of the claw. The claw is attached to the last tarsal segment by a strong tendon, which is slightly chitinized at its junction with the lower base of the claw and is conspicuous as a heavy cord.

The comparative length of the tarsal segments varies considerably, and this feature may be used as a specific character but it is of doubtful value. Usually the segments increase in length from in front backward, the hind tarsi being the longest. In most cases the first and second pairs of legs show this difference only slightly, while the hind tarsi are easily seen to be much longer than the others. A notable exception to this occurs in the subfamily Hoplophorinae, in which the hind tarsi are very much shorter than the anterior or the intermediate ones (Plate XXXVI, 27–29). This is the character on which the forms of this subfamily are separated and it is apparently reliable. The relative smallness of the posterior tarsi in these forms is made more conspicuous because of the fact that the posterior tibiae are much swollen at their distal ends, making the comparison between the tibiae and the tarsal segments all the more noticeable. It is interesting to observe that when any tarsal variation

occurs in the Membracidae it appears in the hind leg rather than in either of the others.

The tarsi are much given to pubescence and hairiness. In some species this development is so remarkable as to be used in diagnosis, and unusual development of spines has been used as a generic character for the genus Antianthe (Fowler, 1894–97: 137). In the subfamily Centrotinae the bristles, spines, or hairs are so numerous in many species as to completely hide the other structural characters of the tarsus.

Aside from its use as the distinguishing character of the subfamily Hoplophorinae, the tarsus has been little used for systematic purposes in the study of the Membracidae. There is little doubt but that enough variation exists to warrant more careful consideration of this part of the leg, and a further study of the hind tarsus may yield good taxonomic data.

THE ABDOMEN

The abdomen consists normally of eleven segments, of which the first is only partially developed and the last two are more or less modified. The arrangement and number of segments is perhaps best shown in the nymph, in which the anal region is represented by a series of telescoping tubes (Plate XXXVII, 5). In this stage the first segment is hidden under the metathorax and the last is poorly developed, but the others are evident. In the adult the abdomen of the insect is so modified in the separate sexes as to require separate descriptions. The following general facts, however, may be noted.

Each segment from the second to the seventh, inclusive, is ring-like in form and consists of a distinct tergum, pleuron, and sternum. The first segment consists of a tergum only (Plate XXXVII, 4), and this sclerite is only partially developed, the lateral extremities being shortened. The abdominal *terga* are long, horseshoe-shaped sclerites covering not only the dorsum but most of the lateral areas. They end in rather a sharp angle at the junction of the pleura. The *pleura* are short and subrectangular (Plate XXXVII, 1), and are located on the ventral rather than the lateral part of the abdomen. The first eight abdominal pleura bear *spiracles* in the extreme cephalic mesal angle of the sclerite. The spiracle for the first segment is, indeed, not in the chitinized part of the sclerite at all, but is located in the membrane between this sclerite and the metathorax in such a position that it appears as a part of the latter segment.

PLATE XXXVII

1, Ventro-lateral view of abdomen of female, showing spiracles
2, Spread abdomen of *Enchenopa binotata* Say (female), showing relative position of sclerites
3, Ventral view, 4, lateral view, of abdomen of female, with segments numbered; 6, dorsal view
5, Arrangement of abdominal segments in nymph
7, Cross section of abdomen, showing form and position of sclerites
8, Ventral view of abdomen of female, with styles separated

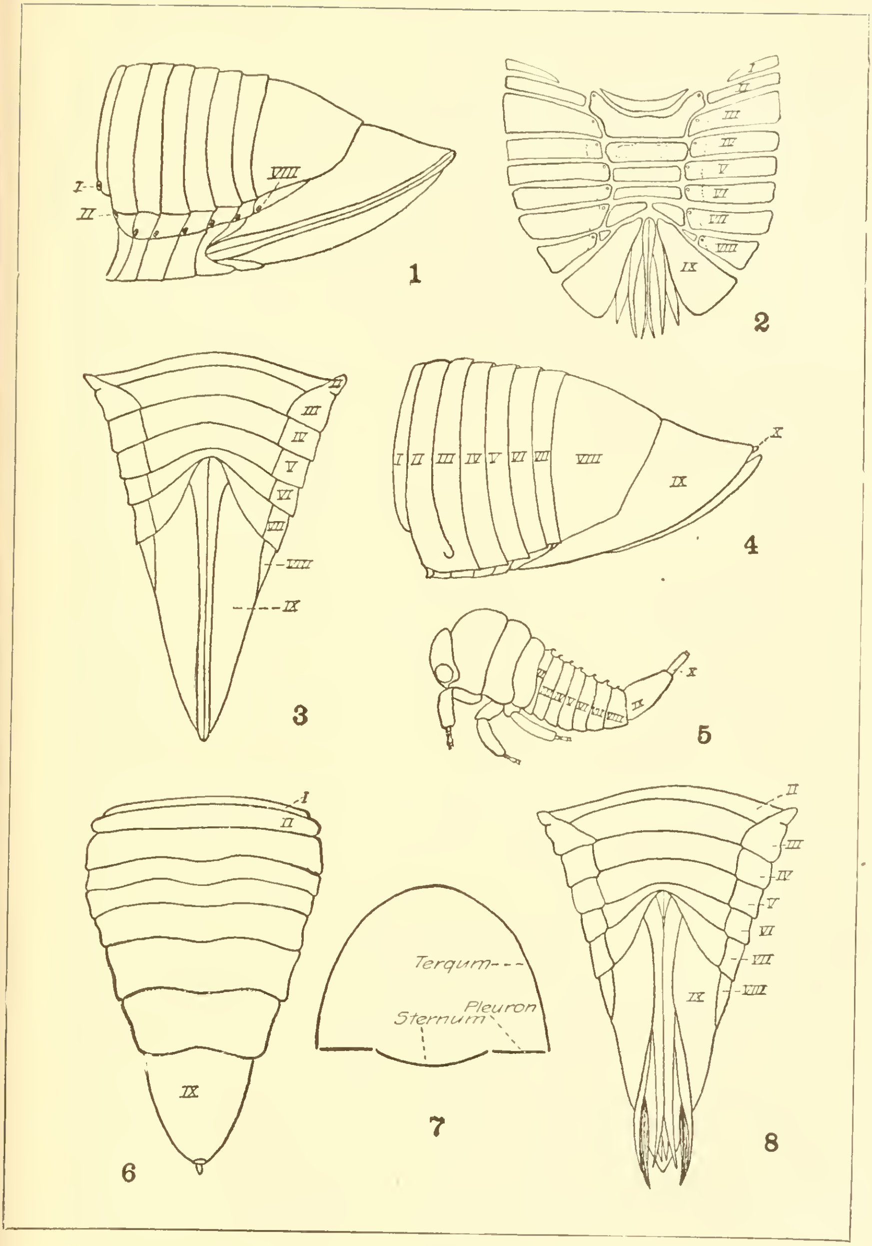


PLATE XXXVII

The positions of the thoracic spiracles, however, show that this one is a part of the first abdominal ring, and a section of the early nymphal stages leaves little doubt as to the correctness of this interpretation. The spiracle of the second segment, likewise, is usually found at the very edge of the sclerite if not actually in the membrane (Plate xxxvii, 1). The *sterna* are uniform in the anterior region of the abdomen (second to seventh segment, inclusive), but are modified in the posterior region in the two sexes. Each sternum is typically a long curved plate forming the ventral floor of the segment and connecting the pleura of each side. Usually it is smooth and unsculptured. The abdomen is much thicker at the anterior than at the posterior end, and for that reason the anterior sterna are the longest and widest (Plate xxxvii, 3).

The individual sclerites vary in certain respects in different genera, but on the whole they show no difference important enough to warrant special discussion. The relation of the various sclerites to one another is seen in Plate xxxvii, 2, in which the entire abdomen, cut along the median dorsal line, is shown as spread out flat. This species (*Enchenopa binotata*) of the subfamily Membracinae shows the more extreme type of variation. It will be noted that the first two sterna are rather peculiar in shape, the seventh is subdivided, and the eighth is represented only by two small triangular pieces. Aside from these not unusual peculiarities, the abdomen as figured may represent the usual structure in the female.

From an external view of a complete insect very little of the abdomen is visible. The projecting posterior process of the pronotum hides the dorsal surface, while the two pairs of wings fold tightly against the lateral regions and conceal these areas. For these reasons the dorsal and lateral parts of the abdomen are not suited for taxonomic study. It is doubtful, however, whether these areas would offer characters of value even if they were plainly visible. The color of the abdomen is usually uniform and agrees with the general color of the remainder of the body. The undersurface is generally darker than the upper, and the segments are in some cases bordered with a lighter shade than that of the ground color. The anterior end of the abdomen is inclined to be of a lighter hue than the posterior, and all the segments are likely to vary in this respect within a species. The entire abdomen, and particularly the ventral surface, is much given to pubescence; this is very noticeable in certain forms along the pleural sclerites. Occasionally the white tomentose patches are found

on the abdomen as on the thorax. When present these are usually on the lateral areas of the first three segments and show thru the basal part of the wing. The terga are often punctate, but this condition is seldom seen on any part of the abdomen, and even on the terga the punctures are much less developed than on the head or the thorax.

Each segment of the abdomen is smaller than the one before it, so that the posterior margin of one segment overlaps the anterior edge of the next; and the segments decrease in size rapidly toward the apex of the body. In general the terga extend as far ventrad as the lowest line of the abdomen, the pleura project almost horizontally, and the sterna curve ventrally in a slightly convex line (Plate xxxvii, 7). The undersurface of the abdomen has been used in specific descriptions by various authors, but it cannot be depended upon as presenting structures of value, since both shape and color vary with the biological condition of the insect. The presence of hairs and other forms of pubescence is a more reliable character, but even this is not constant.

Altho the abdomen of the adult insect is of little importance for taxonomic study, the same region in the nymph abounds in characters that are of much value. The most noticeable of these characters are the spines, which in the immature insect arise from the dorsal surface of each abdominal segment. These spines are of many shapes and sizes, and differ in the various instars to such an extent that they may be used not only to identify the species but also to determine the nymphal stages represented (Funkhouser, 1915 b: 148–150). The nymphal abdomen also shows interesting color patterns which are of assistance in the determination of such material (Matausch, 1912 b). Again, the position and structure of the anal tube in the nymph has been found of value in systematic work, and the latero-ventral teeth might doubtless be used in the same way. All these structures (Plate xxiv, 2, 10, 15) usually disappear after the fifth instar, and the newly emerged imago shows few signs of the nymphal decorations. The dorsal spines persist in a few species of the subfamilies Membracinae and Centrotinae. It may be remarked that on examination these spines prove to be merely extensions of the most external part of the body wall, and are believed to be without function. Some of the larger projections are hollow, while the smaller are bristle-like.

The *anal tube* in the nymphal forms is deserving of special mention, not particularly because of its structure, which is not unusual, but because

of its biological use. It is from this tube that the honeydew is ejected which is so eagerly sought by ants. There can be little doubt that this substance is entirely excretory in nature and probably represents nothing more than the usual intestinal waste product. Its elimination, however, in those species attended by ants, is a process of some interest. When approached by an ant, the membracid nymph elevates the ninth abdominal segment to almost a right angle with the body. The ant then strokes this segment with its antennae and forelegs, upon which the membracid protrudes the anal tube and exudes from this segment a drop of clear liquid which is at once taken by the ant. Not all species are attended by ants, but the anal structure seems to be about the same thruout the family. In some cases the adult as well as the nymph gives off this secretion. Careful histological study fails to reveal the presence of glands in the anal region, and there seems to be no physiological provision for any special secretions which might differentiate the waste of one species from that of another; so that the particular element which causes certain species to be sought after by ants, and others to be ignored, is not known.

The *apical segment* of the abdomen of the adult can be discussed only in relation to the different sexes, since the modifications in the sclerites caused by the development of genital organs are quite distinct in the male and the female.

The female

The genital structure in the female is shown in Plate xxxvii, 6, 8. The sterna of segments ii to v, inclusive, are comparatively uniform, each being a broad, flat, slightly curved plate extending across the abdomen. The sixth sternum is indented at its median posterior margin, and the entire ventral part of the segment is usually much recurved. The sternum of the seventh segment is deeply notched in its median part to inclose the rounded base of the ovipositor. This is the last entire segment in the female abdomen and its shape varies greatly according to the type of ovipositor surrounded (Plate xxxviii, 1-10). The structure of this sternum has been used successfully as a specific character in the genus Stictocephala (Van Duzee, 1908 a:42) and will doubtless be found valuable in other genera. In some cases the sternum is so deeply indented that from an external view it appears as two separate sclerites. The eighth segment may or may not show a sternum, but if one is present it is reduced

to a small triangular sclerite on either side of the ovipositor and does not extend entirely across the abdomen. In most cases no sternum occurs in this segment. The ninth abdominal segment consists only of the tergum, but this sclerite is much enlarged and makes up the larger part of the posterior end of the body. This segment is not represented by a pleuron in any species dissected and no spiracle is present to suggest such a structure. The sclerite bends around to form most of the body wall. The free ventral edges do not meet, but the space between them is occupied by the styles of the ovipositor. This segment is most inclined to show pubescence and well-developed hairs, and is the most conspicuous part of the female abdomen. The tenth and eleventh segments are more or less vestigial and are usually hidden under the posterior projection of the ninth. On dissection, however, they appear as very small tergal plates with a weakly chitinized ventral ring (Plate XXXVIII, 11, 12). In fresh material the segments may be dissected out, in which case the tenth segment appears as a complete ring with the dorsal surface firm and the remainder of the ring membranous (Plate XXXVIII, 13). On boiling in caustic potash the lateral and ventral parts of the segment sometimes disappear, leaving only the dorsal plate. The eleventh segment appears merely as a small triangular piece with membranous extensions. While these last two segments are much reduced, they no doubt represent the regular tenth and eleventh abdominal rings, and, as will be noted later, are more easily recognized in the male. The same interpretation has been made by Berlese (1909:263) for other Homoptera and seems entirely logical.

The *ovipositor* consists of three pairs of styles. The outer pair is the longest and incloses the middle pair, which in turn surrounds the inner. The *outer styles* (Plate XXXVIII, 14, 15) are roughly forceps-shaped, narrowed at the base, wide and flat at the center, and hollowed out on the inner surface to form a spoon, or paddle, the excavated part containing the middle styles. The edges are smooth and the tips pointed. The outer styles project below and beyond the ninth abdominal segment and are plainly visible from an external view of the insect. They are often densely pubescent, but seldom punctate. They are tightly closed except during oviposition and mating, and form a smooth, rounded, ventral surface for the apical end of the abdomen. The *middle styles* (Plate XXXVIII, 16, 17) are slightly smaller, narrower, and shorter than the outer styles, and fit

PLATE XXXVIII

1, Last ventral segment of female of *Stictocephala collina* Van Duzee; 2, of *Stictocephala festina angulata* Van Duzee; 3, of *Stictocephala inermis* Fabricius; 4, of *Stictocephala pacifica* Van Duzee; 5, of *Stictocephala substriata* Walker; 6, of *Stictocephala festina* Say; 7, of *Stictocephala diminuta* Van Duzee; 8, of *Stictocephala lutea* Walker; 9, of *Stictocephala Wickhami* Van Duzee; 10, of *Stictocephala Gilletti* Goding

11, Ventral dissection, 12, cross section, of apical end of abdomen; 13, tenth and eleventh abdominal segments dissected from the ninth

14, Dorso-lateral view, 15, ventral view, of outer styles of ovipositor

16, Dorso-lateral view, 17, ventral view, of middle styles of ovipositor

18, Dorso-lateral view, 19, ventral view, of inner styles of ovipositor

20, Dorsal view, 21, ventral view, of abdomen of male; 22, lateral view of abdomen of male, with genitalia labeled

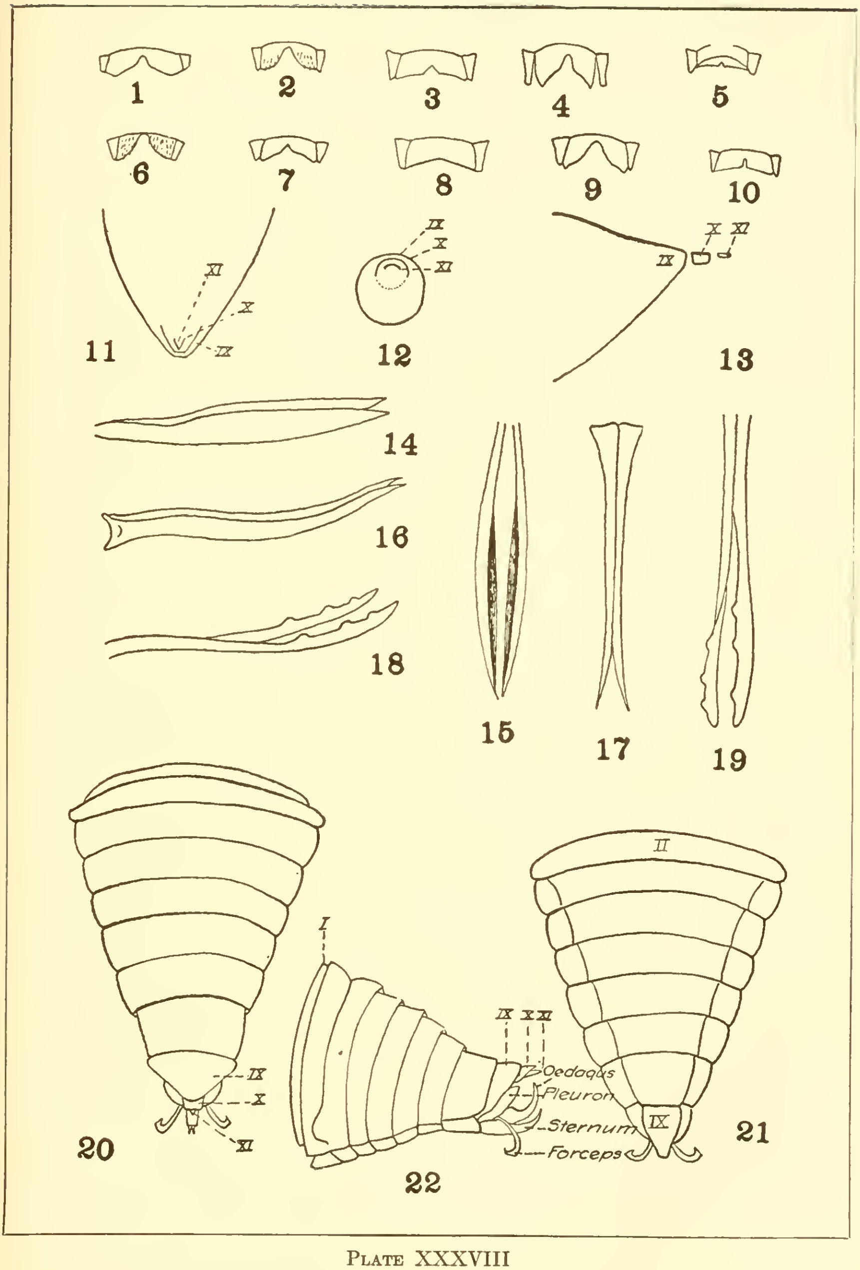


Plate XXXVIII

snugly into these. The base of the middle pair is flattened and expanded to form an articulatory joint (Plate XXXVIII, 16) resembling the lower maxillary joint of mammals. The shafts of the styles are doubly curved, the edges are smooth, and the extremities are very sharp. Like the outer styles, the middle pair are close together when not in use. The *inner styles* (Plate XXXVIII, 18, 19) are again forceps-shaped, the shafts being narrow and about equal in width thruout their length. The lateral and ventral margins of these styles are smooth, but the dorsal edge is thrown up into teeth, or nodules, of which there are from two to five on each style. Since the inner styles are located deeply within the other two pairs, they are not visible except on dissection.

The abdominal structures of the female show few characters suitable for taxonomic work. Aside from the shape of the last sternum, which has already been discussed, no parts of the abdomen of this sex have been used by systematic workers in the family for purposes of classification.

The male

The abdomen of the male differs from that of the female chiefly in the structure of the apical areas. As a whole the abdomen of the male is flatter, shorter, less robust, generally darker in color, and more inclined to pubescence, and the segments are more closely telescoped (Plate XXXVIII, 20–22). The extremity is more regularly and narrowly pointed. The tenth and eleventh terga are usually quite distinct and often project some distance beyond the ninth (Plate XXXVIII, 22). The ninth segment is modified, but in a different way from that seen in the female. In the female this segment shows no pleuron nor sternum, but the greatly enlarged tergum folds around the entire abdomen; in the male all the parts of the segment are apparently present, the pleura projecting as separate sclerites on each side or joined below, and the sternum produced and curved upward at the extremity. The first segment is modified as in the female, but the median segments are normal.

No modifications of the abdomen for the production of sound, such as the timbal and mirror of the cicada, are present. So far as is known, no species of membracid has any sort of sound-producing apparatus and the only noise made in the field is the sharp whir of the wings in flight.

The Membracidae are not characterized by the noxious odors common to many forms of the Hemiptera. The spiracles have been confused with

supposed stink glands (Buckton, 1903:18), but no signs of the latter structures are shown in histological preparations.

The *male genitalia*, while comparatively simple in structure, are extremely interesting and are well deserving of more serious study than has been given to them in the past. Occasional attempts have been made to use the male genitalia for systematic purposes, but with little success. It is not unreasonable to believe, however, that these structures, which have proved of so much value in other groups of insects, should be equally distinctive in the Membracidae if the characters are patiently diagnosed for a large number of genera. It may naturally be supposed that sexual organs undergo less change when the insects are forced into new conditions and environments than do motor or protective structures, and, being less plastic, would preserve their characters and readily yield themselves to generic classifications. A tentative study has seemed to show that this is indeed the case. The organs have become modified in form and have developed various types of claspers, styles, and prongs, but the necessity of retaining the function of the organs has kept these modifications within bounds. Fowler (1894–97:2) states, regarding the Membracidae:

> It is probable that good characters may eventually be found in the male organs in certain genera; but, except in one or two cases, I have found them of very little practical value as yet, and this will be the case until more material for dissection is provided.

The same author has, however, used these characters successfully to distinguish the genera Ceresa and Stictocephala (pages 87, 102, 108, of same reference), and the differences noted appear to be well chosen and entirely satisfactory. Commenting on this character Van Duzee (1908a:42), in his discussion of the genus Stictocephala, states:

> Canon Fowler in the Biologia does not trust to the form of the pronotum but claims to have found other characters in the form of the male genitalia that are sufficient. I have however been unable to detect any such characters as he mentions without dissection of the insect, which generally is out of the question, and prefer to distinguish the genus on the form of the pronotum which I consider amply sufficient.

Van Duzee's criticism is well taken in so far as regards the difficulty of examination. This, indeed, is the objection to the use of the genital characters in the family. It is practically impossible to determine their structures without the destruction of the insect, and this, as Van Duzee states, is often entirely out of the question. The usual methods of relaxing or spreading the specimen, or the softening and pulling out of the

genital apparatus, are not adaptable to the Membracidae, since in this family the tip of the abdomen not only is generally concealed by the posterior process of the pronotum but is often folded entirely within this structure. Since the pronotum is strongly chitinized and very rigid, and since the abdomen is not long enough to be extended beyond or pulled below this covering, the examination of the genital apparatus is, in a large number of species, rendered decidedly difficult if not impossible.

Nevertheless there are a number of reasons why the anatomy of the genital organs should be worked out and their taxonomic importance noted. In the first place, the known usable taxonomic characters of the Membracidae are extremely limited and any additional data on the subject are of great value. Again, there are many forms that lack the heavy posterior pronotal process, and in these the apex of the abdomen may be easily studied. Moreover, even in forms in which the abdomen is partly covered, it might often be possible to discern the particular characters necessary for diagnosis when all others are obscured. And finally, if the genital character gave absolute evidence it might often be worth while to dissect one specimen of a series in order to establish the validity of other specimens. For these reasons the structure of the male genitalia is here discussed in some detail in order that it may serve as a basis for more extended work on the subject. The actual value of such data can, of course, be known only when comparison is made of a large number of genera. Such a task is beyond the scope of this study, but the resultant data are much to be desired.

The literature relating to the structure of male genitalia in Hemiptera is very meager and the work done has been in rather widely separated families. Of the published works on the subject, the short report by Blümml (1899) on the Psyllidae shows conditions which more nearly approach those of the Membracidae than have been noted in any other family of Hemiptera. This bears out Crawford's (1914:16) suggestion that the relation of the psyllids to the Cicadidae and the Membracidae is probably close. The psyllids show, however, an arrangement of genital parts which, while homologous, is not strictly comparable to that of the membracids. The fact that the workers in various groups have been more or less independent of one another in the matter of terminology has resulted in a slight confusion of terms; but, since the structure of the membracid organs is comparatively simple, this subject needs no dis-

cussion in connection with the family. Whenever possible the terms used in this study have been those defined in the very complete reports on the lepidopterous genitalia by Pierce (1909 and 1914), while other structures have been described in terms relative to the parts of the abdominal segment.

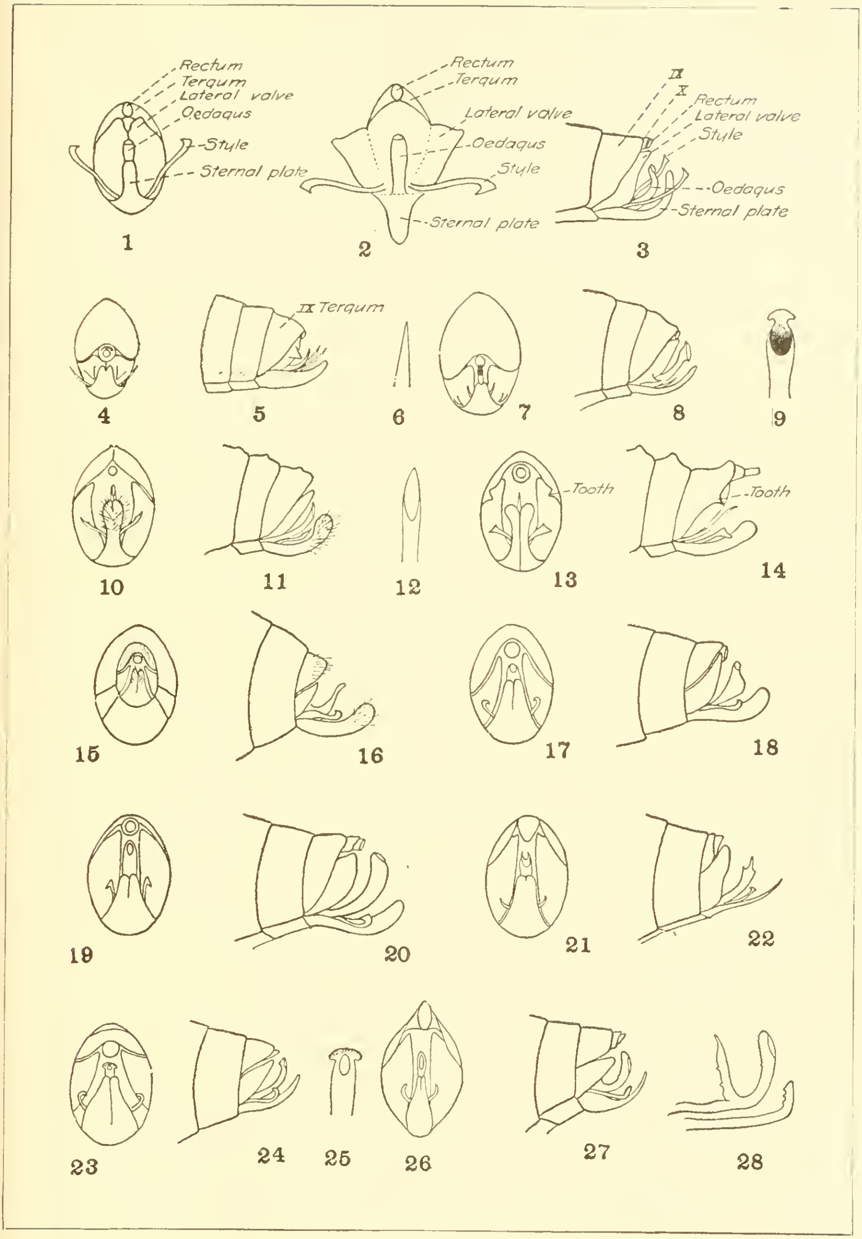
It is apparently not yet decided how many segments are theoretically comprised in the development of the genital apparatus in either sex in the Hemiptera, but a knowledge of this subject is not necessary to a discussion of their external anatomy, nor does it affect the value of the structures for taxonomic use. The homologies of the parts in these as compared with other insects have not been determined, but it would seem that the Homoptera in general show a far less complicated arrangement of abdominal appendages than most of the orders for which these organs have been described.

The male genital organs of the Membracidae are not covered by any parts of the abdomen proper, altho they are more or less protected by the posterior process of the pronotum in some species and by the tips of the wings in most. Sharp (1890) has noted that in the Pentatomidae the male genital apparatus is exposed and incapable of being withdrawn into the body. He contrasts this with the protected parts in the Coleoptera, and explains the difference on the ground of the different method of copulation in the two orders. Unfortunately this author deals with the Pentatomidae only, and in this heteropterous family the arrangement of the genitalia is very different from that found in the Membracidae and Sharp's excellent figures offer little suggestion of homologies. The exposed genital chamber, or *terminal chamber* as it is designated by Sharp, is, however, common to both families. This term may be used to designate the external opening of the posterior abdomen below the rectum, which contains the structures in question. In the Membracidae it hardly deserves the name *chamber* in the sense of an inclosed cavity, since the appendages are all comparatively superficial.

The genitalia are shown diagrammatically in Plate XXXIX, 1, 2, in which the first outline represents the parts in their normal position and the second shows the same parts as dissected and spread apart. The *tergum* of the ninth abdominal segment overlaps and partially surrounds the *rectum*, which is located at the extreme dorsal angle of the exposed end. Below and on either side are two broad plates which are here termed,

PLATE XXXIX

1, Male genitalia, parts in position; 2, parts spread; 3, lateral view
4, Male genitalia of *Ceresa bubalus* Fabricius, caudal view; 5, lateral view; 6, tip of oedagus
7, Male genitalia of *Stictocephala festina* Say, caudal view; 8, lateral view; 9, tip of oedagus
10, Male genitalia of *Enchenopa binotata* Say, caudal view; 11, lateral view; 12, tip of oedagus
13, Male genitalia of *Oxyrhachis tarandus* Fabricius, caudal view; 14, lateral view
15, Male genitalia of *Platycotis sagittata* Germar, caudal view; 16, lateral view
17, Male genitalia of *Telamona ampelopsidis* Harris, caudal view; 18, lateral view
19, Male genitalia of *Thelia bimaculata* Fabricius, caudal view; 20, lateral view
21, Male genitalia of *Entylia sinuata* Fabricius, caudal view; 22, lateral view
23, Male genitalia of *Vanduzea arquata* Say, caudal view; 24, lateral view; 25, tip of oedagus
26, Male genitalia of *Atymna castaneae* Fitch, caudal view; 27, lateral view; 28, oedagus and styles



Rectum
Tergum
Lateral valve
Oedagus
Style
Sternal plate
Rectum
Tergum
Lateral valve
Oedagus
Style
Sternal plate
IX
X
Rectum
Lateral valve
Style
Oedagus
Sternal plate
1
2
3
IX Tergum
4
5
6
7
8
9
Tooth
Tooth
10
11
12
13
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PLATE XXXIX

for want of a better name, the *lateral valves*. These are sometimes folded inward to meet each other, and sometimes they project directly caudad leaving the lower surface of the anal tube exposed. When the latter condition obtains, or when the lateral valves have been dissected away, the ventral part of the rectum is seen to consist of a somewhat chitinized plate which is probably the vestigial sternum of the tenth segment. The area below the rectum and cephalad of the valves is occupied by the intersegmental membrane. From the region between and at the base of the valves arises the *oedagus*. This structure is heavy and curved (Plate xxxix, 3), extending first caudo-dorsad, then dorsad, and then dorso-cephalad. Near the base of the oedagus arises a pair of *styles*, or forceps, which usually extend outward laterally and are subject to great modification in shape. The *sternal plate*, which is apparently the sternum of the ninth segment, bends almost directly upward at its tip and in some species extends so far dorsad as to form a posterior wall behind the oedagus (Plate xxxix, 3). The oedagus contains the *penis*, a long, white, filamentous tube which is seen only on dissection.

The variation in position and structure of the parts of the genital apparatus is considerable (Plate xxxix, 4–28), and it is this variation that suggests their taxonomic importance. So far as has been studied such variation is largely generic, and the figures have been purposely drawn from a rather wide range of genera. From their position the various plates seem to be only modifications of normal sclerites of the abdominal segments, but this assumption may prove incorrect if embryological evidence is obtained. In fact the paired condition of most of the plates — even the sternal plate, which superficially appears to be merely the extension of the ninth sternum — would suggest the possibility that these structures are true appendages, homologous with the very generalized developments on the abdomens of such low forms as certain Thysanura.

The *terga* of the ninth, tenth, and eleventh segments are usually visible in the male. In some cases the tenth and the eleventh are hidden within the ninth (Plate xxxix, 5) and in some cases they are projected (Plate xxxix, 14); but in all cases they cover the anal tube and form a dorsal roof over the rectum. The ninth tergum is the only one suitable for taxonomic use, and this is usually best seen from a lateral view. From this aspect the sclerite appears as a subtriangular piece (Plate xxxix, 5)

extending almost to the pleural line. This tergum may project almost directly caudad so that the rectum is located very near the dorsal margin of the segment and very little of the tergum is visible from a caudal view (Plate xxxix, 18); or it may extend well ventrad so that the rectum appears nearly in the center of the segment and a large part of the tergum appears from a caudal view (Plate xxxix, 4) as a broad sloping roof. In some cases the entire ninth segment is so small in diameter that from a caudal view the eighth segment is visible around it (Plate xxxix, 15). In some species the tergum is armed with teeth on each side (Plate xxxix, 14), such teeth probably functioning in the process of copulation. In a very few forms, particularly in the subfamily Membracinae, the tergum shows signs of median subdivision (Plate xxxix, 10), but this is shown only after boiling in potash. Occasionally the tergum shows a process, or projection, on the median dorsal line (Plate xxxix, 10, 13), which is probably the remains of the nymphal spines of that segment. In many cases the sclerite is pubescent (Plate xxxix, 15), and the hairs may be developed to such an extent as to overhang and hide the rectal opening. The variation in lateral length may range from an almost complete arch (Plate xxxix, 15) to a very narrow strip extending hardly one-third of the distance toward the pleural line (Plate xxxix, 21).

The *lateral valves* are always present and are of considerable importance. From their position they would appear to be modifications of the pleura of the ninth segment, but, as has been suggested, this may be an incorrect interpretation. For systematic purposes the character most easily determined is whether they project directly caudad (Plate xxxix, 24) to continue the lateral line of the abdomen, or turn inward to meet under the rectum (Plate xxxix, 1) and form a posterior wall for the body cavity and an anterior wall before the oedagus. This is believed to be a constant and valuable generic character. In size the valves vary from narrow, triangular sclerites (Plate xxxix, 15) to broad, flat plates (Plate xxxix, 20) which occupy most of the lateral surface of the segment. They are often armed with teeth (Plate xxxix, 5, 8), but the position of these teeth is variable as shown in the figures. Like the terga, these sclerites are often pubescent. In general the lateral valves seem to have little protective function, since the oedagus is well caudad, and they are probably used as copulatory organs of attachment. Whether

they are homologous with the *harpes* of the Lepidoptera can be determined only by a comparative study of the two orders.

The *oedagus*, or penis sheath, is a heavy, partly chitinized covering for the penis. It is apparently of one piece and does not show the segments described for this organ in other orders of insects. In composition it is substantial enough to withstand the boiling and clearing necessary for examination under the microscope, and usually stands out well in such mounts. The oedagus seems to arise from the very base of the ninth segment, between the bases of the lateral valves and the sternal plate. Such an origin would agree with that found for the organ in certain beetles, and fairly well with the same structure in other orders. Muir (1915:151) states: "The oedeagus arises as a tubular organ at the base of an intersegmental invagination between the ninth and tenth sternites."

The function of the organ is undoubtedly protective, and it may be noted that practically no other protection is afforded to the penis since the entire genital chamber is so openly exposed. The oedagus itself is apparently of sufficient strength and rigidity to need no protection, altho in other orders it is generally covered by some parts of the genital chamber. In this connection Sharp (1890:421–422) states:

> It appears to be a great comfort or advantage to insects to be able to withdraw and cover over some of the sensitive parts of the body during repose, or when the parts are not in use . . . . . It is therefore quite consistent with what we find to obtain in insect economy that the alimentary canal . . . should be made to protect the oedeagus, and the fact justifies us to some extent in inferring that the oedeagus, or some part of it, is a sensitive organ; but it is, on the other hand, equally probable that the delicate structures of the oedeagus are covered simply to preserve them from injury.

In shape the oedagus is uniformly curved, bending upward and forward so that its apex points toward the rectum. It varies greatly in diameter in different genera and the tip is inclined to be much modified. Often the entire organ is gradually acuminate and sharp at the extremity (Plate XXXIX, 6); again, the tip may be swollen and surmounted by a knob-like projection (Plate XXXIX, 9). These two forms are the ones used by Fowler (1894–97) to separate the genera Ceresa and Stictocephala, and are believed to be sufficient characters for such distinction. In Stictocephala the apex of the oedagus is so broadly expanded, bell-shaped, and prominent as to be easily determined from a lateral view, and should serve as an excellent taxonomic character. The organ may be much swollen just below the apex (Plate XXXIX, 18, 20) — and occasionally

the apex itself is hollowed out anteriorly and posteriorly (Plate xxxix, 22, 23) — or surmounted by a heavy, punctate bar (Plate xxxix, 25). The opening for the penis is almost invariably on the posterior surface of the apical end (Plate xxxix, 12, 20, 25, 28). Even when the opening is strictly apical the oedagus is bent to turn the apex caudad so that the relative position is the same (Plate xxxix, 16, 17).

A peculiar structure is noted at the base of the oedagus in certain genera of the subfamily Smiliinae (Plate xxxix, 28). This consists of a stiff, toothed, internal appendage arising from the base of the curved external arm and extending almost directly dorsad into the eighth segment. Its function has not been determined.

The oedagus is usually smooth and without pubescence or hairs; its apex is occasionally punctured.

These variations are believed to be entirely sufficient for taxonomic use and should at least prove valuable as supplementary characters. In many cases the tip of the oedagus is protruded in the mounted insect, making the examination of the part possible. For this reason it is considered one of the most important parts of the genital apparatus from the standpoint of the systematist.

The *penis* is difficult to locate except in very fresh material. Since its structure is a problem of internal rather than external anatomy, no attempt has been made in the course of this study to work out its morphology. On superficial examination it appears to be a long, whitish filament, its length being surprising as compared with that of the oedagus. No indication has been found of any structure homologous to the *praepenis* as described by Harnisch (1915) for certain Coleoptera, nor do there appear to be any important variations in the basal structure of the organ.

The *styles*, or forceps, are very apparent in the Membracidae and in many forms extend far enough out of the genital chamber to make examination possible in the mounted specimen. Only one pair of these organs is present and the relative position in the segment is comparatively uniform thruout the family. Each style arises from the lateral margin of the segment near its base and usually between the lateral valves and the sternal plate (Plate xxxix, 14). On dissection it is seen that the base extends into the abdomen and originates in the seventh segment (Plate xxxix, 5). This can be seen in a well-cleared mount of the abdomen in toto. The style projects almost directly caudad and sometimes slightly

laterad (Plate XXXIX, 10, 11). In shape the basal part is comparatively straight and the distal end bends upward in a gradual curve (Plate XXXIX, 5, 16, 18, 24) or sharply at an angle (Plate XXXIX, 27, 28). The tip is the most inclined to variation, and may range from a sharp, needle-like point (Plate XXXIX, 5, 8) to broadly angled plates (Plate XXXIX, 14, 22) or sharply toothed hooks (Plate XXXIX, 16, 27).

Study of the process of copulation in the living insects proves the function of the styles to be that of clasping or interlocking organs, as their shape would indicate. The terminal hook or angle always turns upward and in some cases forward. In a few species examined, the styles act in conjunction with the teeth of the lateral plates in the mating process.

As in the case of the oedagus, the structures of the styles offer good taxonomic characters and may be found useful in a number of genera.

The *sternal plate* is apparently a modified abdominal sternum, but its tendency to subdivision would suggest that it may be a fused or partly fused pair of appendages. The plate originates at the base of the ninth segment and is attached to the eighth abdominal sternum. It projects first caudad and then dorsad and is the most posterior of the genital organs. It may extend only a short distance upward (Plate XXXIX, 7), or it may extend so far in this direction as to hide the other genitalia when viewed from a caudal aspect (Plate XXXIX, 4, 15). As has been noted, it usually shows a division down the median line. This division may show only a slight notch (Plate XXXIX, 4), or the separation may be so apparent as to show two distinct plates (Plate XXXIX, 13); but in almost every case the two halves of the plate may be pulled apart after boiling in caustic potash, showing the real structure of the sclerite. For systematic purposes the appearance of the plate in the complete insect, rather than a theory as to its anatomical condition, is of course of more practical importance. This can usually be best ascertained from a strictly caudal view, and the characters most easily noted are the comparative length of the plate, the shape of the upcurved part, and the amount of splitting at the tip. All these points show sufficient variation to aid in diagnosis and all are relatively constant.

The sternal plate is usually pubescent and often covered with stiff, bristle-like hairs (Plate XXXIX, 10). It is freely movable and in the relaxed specimen may be pulled far downward without injury to itself or to the remainder of the genitalia. It may often be examined by merely

separating the wing tips, and for that reason is the best adapted of all the genital parts for systematic work.

On the whole the male genitalia afford good taxonomic characters. The parts are simple and easy to dissect. The relative position of the plates and the structure of the individual pieces show sufficient variation thruout the family, and are constant enough within a genus, to furnish valuable data at least to supplement the more evident characters of the exoskeleton.

INTERNAL ANATOMY OF THE MEMBRACIDAE

The internal anatomy of the membracid does not, on the whole, differ enough from that of other Hemiptera to warrant special discussion. The digestive system, however, is peculiar and shows some of the striking characters described by Kershaw (1913) for the species *Tricentrus albomaculatus* Dist. of the subfamily Centrotinae. This exotic species shows a formation of the mid-intestine much resembling that described by Witlaczil, Lang, and Packard for the Psyllidae (Packard, 1898:320).

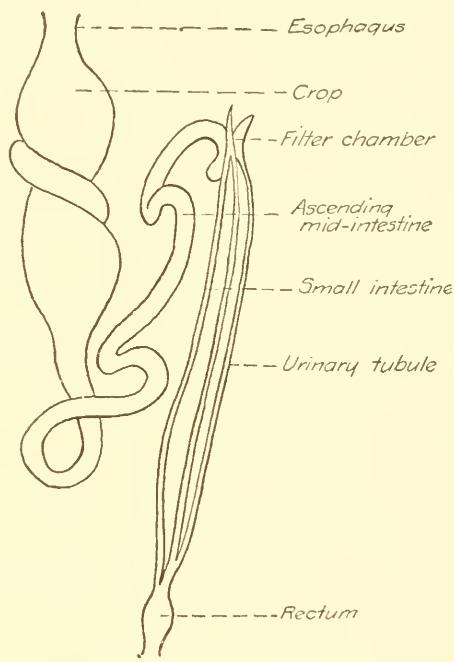

FIG. 42. STRUCTURE OF ALIMENTARY CANAL

No species of the Centrotinae have been available for dissection locally and the specimens examined in the course of this study have all been from the subfamily Smiliinae. These show some decided variations from the type described by Kershaw, the most noticeable difference being in the number and position of the urinary tubules.

The alimentary canal is short and much twisted (fig. 42) and the various parts are strikingly distinct in size and structure. The short esophagus opens directly into the crop, which is very large and has a peculiar twist

at its center. At the posterior end of the crop the canal is much narrowed to form an ascending mid-intestine, which bends abruptly anteriorly, is irregularly coiled and twisted, and extends forward as far as the center of the crop. At the end of the ascending mid-intestine is a knot from which arise two urinary tubules; each of these tubules has a blind end projecting a short distance cephalad, while the tubule itself extends along the full length of the small intestine and joins the rectum by the side of the small intestine. From the knotted end of the mid-intestine arises the small intestine, which is very narrow in diameter and almost straight. The small intestine opens into the swollen rectum, which connects by a smaller rectal tube to the opening in the abdomen.

At the point where the mid-intestine ends and the small intestine begins, both these organs are somewhat looped and give rise to the urinary tubules. This part of the intestine has been called the filter chamber, and has been described in the Cercopidae by Licent (1911); but in the type of chamber shown by that family the mid-intestine and the urinary tubules are twisted many times around one another in an inclosed part of the canal. A similar filter chamber, tho not so elaborate, is described by Berlese (1909:733) for certain Coccidae.

Apparently such an arrangement of twisted intestine and nephridial organs is not uncommon in the Homoptera. The points of distinction to be noted in the subfamily Smiliinae are the two, rather than four, tubules and the peculiar caeca-like projections at the anterior ends of these tubes.

The respiratory system shows no peculiarities so far as has been observed. The spiracles have been discussed under the description of the external anatomy.

In the reproductive system the only points noted as applied particularly to the Membracidae are the number of eggs found in various species in life-history studies. It may be noted in this respect that the eggs are very large in proportion to the size of the insect, and are usually all matured at about the same time.

HISTOLOGY

Histological studies in the Membracidae show more interesting points in the comparative development of the various tissues than in their arrangement. The material has failed to show any but normal conditions in respect

to the types of structure in the various parts of the body or in the organs. In regard to a few of the tissues, however, some space may be given to the discussion of special conditions that appear to be of interest in the family.

As of particular note the development of the chitin may be mentioned. This is deposited very strongly over the entire pronotum, but very weakly on the remainder of the body, due, no doubt, to the fact that the meso- and the metathorax and the abdomen are usually protected by the exaggerated dorsum of the prothorax. The undersurface of the entire body is soft, the beak, along with the interior body parts, being well chitinized. Internally the bases of the genital organs, and often the filter chamber of the intestine, show evidences of chitinization.

There is a surprisingly small amount of fatty tissue in both nymphs and adults. This might be explained in the latter case by the active life of the insect, but the nymphs are decidedly sluggish and heavy-bodied and the significance of the lack of fat in these forms is not apparent.

The musculature of the entire body is unusually well developed. Not only does this apply to the leg muscles, where such development might be expected, but it is equally true of the wing muscles and the muscular layers of the abdomen.

The connective tissue membranes thruout the body are strong and heavy. This is particularly true of the diaphragm-like division walls between the segments of the thorax, between the head and the prothorax, and between the metathorax and the abdomen. The intestine is likewise surrounded at various parts by heavy connective bands.

The nervous system is very poorly developed, and nerve tissue, aside from the ventral nerve cord, is hardly to be distinguished. This fact has been mentioned as one of the evidences of the low phylogenetic rank of the family.

LIFE HISTORY

APPEARANCE IN SPRING

Since most of the local species of Membracidae spend the winter in the egg stage, the first evidence of the family in the spring is the appearance of nymphs from the winter eggs. This occurs during April and May for most of the species, but a few delay emergence until June. Only one species, *Ceresa basalis*, regularly hatches as late as July. The approxi-

mate dates of emergence of the nymphs have been noted in the preceding section of this study with reference to each species, but it may be interesting to note more definitely the field records for certain species.

The first nymphs to appear are those of *Ceresa borealis,* which have been taken on April 15. Nymphs of *Ceresa taurina* are recorded for April 26. *Enchenopa binotata* has been recorded on May 3, *Ceresa bubalus* on May 10, *Ceresa diceros* on May 20, *Vanduzea arquata* on May 29, and *Thelia bimaculata* on May 30. During the first week in June most of the other species appear in rapid succession, and by the first of July all are out that are to be expected.

Meanwhile the two species that are known to winter over in the adult stage — *Entylia bactriana* and *Publilia concava* — appear sporadically in the warmer days and vary the dates of their appearance from season to season according to the weather. The appearance in the field of the adults of most of the species depends of course on the time required for the maturing of the nymphs, which varies with the species. Collecting begins on July 1 and lasts until the end of September.

MATING

Mating begins almost immediately after the insect reaches maturity. For most species this period includes the first two weeks of July. The position assumed in the process is the one not unusual in Hemiptera, with the caudal extremities together and the heads in opposite directions (Plate XL, 1). The insects are usually very sluggish at this time and seldom move unless disturbed. If molested they fall to the ground, not, however, becoming detached from each other. If movement takes place during copulation, the female generally moves forward dragging the male backward behind her. The process has been timed from five minutes to one hour in different species. No forms have been observed in flight while in copula.

During copulation the styles of the male function as clasping organs and the ovipositor of the female is drawn downward and forward.

Species that have more than one brood a year show more or less well-defined mating seasons during the summer; but in most such species the development of the nymphs is so irregular that the broods overlap and mating may be observed thruout the entire summer and fall.

OVIPOSITION

There are a number of rather distinct types of oviposition, as regards both the location of the eggs and the mechanics of the process. The eggs are most commonly deposited under the bark of the younger twigs, generally in wood one, two, or in some cases three years old. In most cases a single narrow slit is made in the bark, the ovipositor not reaching the cambium or, if reaching it, slipping down on one side of the twig between the bark and the wood and not penetrating the xylem. In this slit the eggs are deposited and the bark springs back into place over them. This type of oviposition is illustrated by most of the species of the genera Telamona, Carynota, Cyrtolobus, and Glossonotus. By this method little damage is done to the host, as the injury is not a severe one and quickly heals. Another type of twig oviposition is found in certain species of the genus Ceresa, of which *C. bubalus* is a well-known example. This species makes a curved slit in the bark, and another close beside it in such a fashion (Plate XXIV, 7, page 223) that the wound fails to close and not only affects the growth of the stem but affords entrance for various fungi and for other insects. A similar type of injury has been reported for certain species of Stictocephala on herbaceous stems, in which cases if the stems are small they may be punctured to such an extent as to cause them to break off at the point of injury.

A number of species deposit in the buds of the host. In this type of oviposition the eggs are laid just beneath the outer bud scales and the nymphs emerge at the time when these scales are first opening in the spring. In a few cases the eggs are not entirely covered but project slightly out of the bud tissue. This method of oviposition has little injurious effect on the host, since the outer bud scale, being entirely protective, may be damaged without injuring the plant. In the case of fruit buds the injury may be more serious, but in no case has it appeared to an extent great enough to be considered important. The most abundant of the species that oviposit in the bud are *Ceresa taurina*, *Ceresa borealis*, *Enchenopa binotata*, and *Vanduzea arquata*.

A few species lay their eggs in the leaves. This is notably true of *Entylia bactriana* and *Publilia concava*. The underside of the leaf is chosen for oviposition and the eggs are placed in two rows, one on each side of the midrib. The egg is not entirely within the leaf but the tip

PLATE XL

1, Copulation in *Glossonotus crataegi* Fitch

2, Oviposition in *Ceresa bubalus* Fabricius, showing ovipositor projecting at right angles to the body

(Photographs by H. H. Knight)

1

2

PLATE XL

is plainly visible. The larger, lower leaves of the plant are most likely to show egg masses, probably because these leaves are the ones available in the early spring when oviposition begins. It will be remembered that these two species winter over in the adult stage and are therefore among the first of the membracids to lay their eggs in the spring. The leaf on which the eggs are laid usually withers and dies soon after the nymphs reach maturity. In the case of the thistle and the goldenrod, however, this is not serious to the plant, since the same thing takes place by midsummer as a result of natural conditions whether the leaves are infested or not.

Some species deposit their eggs in both the stems and the buds. This is true of *Enchenopa binotata*, *Ceresa borealis*, and *Cyrtolobus vau*. The choice of the position seems to depend in some cases on the host plant and in others on the season. *Enchenopa binotata*, for example, lays its eggs in the twigs of the locust but in the buds of the butternut; *Cyrtolobus vau* oviposits in the stems during the earlier part of the season and in the buds in the fall.

A number of species choose the axil of a leaf as the spot for oviposition. This seems to be the case invariably for *Telamona ampelopsidis* and occasionally for *Vanduzea arquata*.

One or two species oviposit in the roots or on the base of the stem below the surface of the ground. This peculiar method has been reported by the writer in a former paper for *Thelia bimaculata* (Funkhouser, 1915 b), and has been found true likewise for *Stictocephala festina*.

In all cases the eggs are protected only by the overlying bark or bud scales. The latter protection is probably the more efficacious since the pubescence on the inside of the scale tends to promote warmth and dryness.

The mechanics of oviposition differ decidedly in various species. In most cases the ovipositor is extended at right angles to the body and thrust perpendicularly into the host. Here it remains until all the eggs making the complement of a single egg mass are deposited. The ovipositor seems to move but slightly in the egg slit during the process, altho a decided movement of the abdomen is observable. All the species of the genera Telamona, Glossonotus, Carynota, and Cyrtolobus whose ovipositing habits have been observed show this method of depositing eggs.

In the case of the genus Ceresa the entire egg slit is made first. The ovipositor is inserted perpendicularly and then gradually moved backward during the process until it is almost parallel with the abdomen. During the insertion of the eggs the ovipositor is repeatedly withdrawn from the slit and forced back at a point slightly in advance of the last incision (Plate XL, 2).

Thelia bimaculata makes the egg slit and inserts the eggs at the same time. The ovipositor moves slowly thru the bark, forcing the tissues apart and depositing the eggs in one movement.

With a few species the ovipositor is withdrawn from the host after each egg has been deposited, and reinserted for the next egg. This is true of *Enchenopa binotata* and for all of the species of Stictocephala whose life histories have been studied.

Entylia bactriana lays a number of eggs, then rests, then moves forward along the same slit and deposits more—generally a different number—then rests again, and so on until a complete row has been finished.

The process of oviposition has been observed most commonly in the middle of the afternoon, when the sun is the warmest and the temperature the highest. It is usually noticed also on that side of the tree or plant which is exposed to the most direct rays of the sun at the time when the process is in progress, except in the case of *Entylia bactriana*, which chooses the underside of the leaf. Wildermuth (1915:350) has observed that in *Stictocephala festina* the eggs are usually laid at night or early in the morning, and suggests that the insects avoid extreme temperatures. This has not been found to be the case locally as the field records show, but the fact that Wildermuth's observations were made in a region of very different climatic conditions may explain the lack of agreement of the data.

The number of consecutive ovipositions made by one female varies with the species but has not been greater than five in any species noted. The average is not over three. In most cases the insect after depositing one egg mass moves along the twig for a short distance and repeats the process after a very short interval of rest. One female generally lays all her eggs on one twig or on twigs very close together, and it has never been observed that the insects move from one plant to another during the process.

While ovipositing the insect is entirely occupied with her work and does not respond to external influences. She refuses to be disturbed and

may be touched or pushed without stopping the process. The writer has often attempted to take a female from a branch while oviposition was in progress, and in so doing has broken off the ovispositor, which remained in the egg slit.

The time required for a single oviposition varies from ten minutes to half an hour. Where several egg masses are deposited in succession the resting period between each insertion increases; so that if fifteen minutes elapse between the first and the second, a half hour may elapse between the second and the third, and often several hours before a fourth if so many are made. The same female may, however, continue to lay eggs for several days until a comparatively large number have been deposited. Hodgkiss (1910:87) reports one individual of *Ceresa bubalus* depositing 252 eggs in 59 scars during July and August, and another inserting 212 eggs in 39 wounds during the same period. Essig (1913) states for the same species that two or three hundred eggs are laid by one individual, but he does not specify the time required for such a number to be deposited.

It has not been practicable in the field to attempt to obtain more than daily records of oviposition, and laboratory experiments have not in all cases seemed convincing. These daily records would indicate that four or five egg masses may be deposited during the course of a day, but after that number has been reached the female remains quiescent for at least twenty-four hours, and very probably for several days, before another egg-laying period begins.

The number of eggs in each egg mass does not vary greatly for any of the membracids studied, and shows an average of four, with a minimum of one and a maximum of thirteen. The numbers of eggs in one egg mass as recorded for a number of the commoner species in this basin are shown in the table on the opposite page.

The most usual method of placing the eggs seems to be in a palmate arrangement with the bases close together and the tips projecting outward. In some species the eggs are laid singly, in others in straight rows, and in still others in irregular clusters.

The season for oviposition depends largely on the number of broods a year for the species concerned. If only one brood a season is usual, oviposition begins in July and extends thru September; but if several broods appear each year there is of course a more or less definite egg-

laying season for each brood, tho, as has been remarked in connection with other points in the life history, the overlapping of broods makes such seasons difficult to delimit. The earliest field record for the process is May 11, for *Entylia bactriana*, and the latest is November 10, for *Ceresa basalis*.

Species	Number of eggs in egg mass			
	Minimum	Maximum	Average	Mode
Enchenopa binotata	3	20	6	7
Ceresa diceros	3	8	4	4
Ceresa bubalus	4	11	5	6
Ceresa taurina	1	8	3	4
Ceresa borealis	1	5	4	4
Stictocephala inermis	3	10	6	5
Carynota mera	1	9	3	4
Thelia bimaculata	3	6	5	6
Telamona reclivata	1	4	2	3
Telamona querci	2	5	3	3
Telamona ampelopsidis	3	10	7	6
Cyrtolobus vau	1	4	3	3
Ophiderma pubescens	2	13	7	7
Vanduzea arquata	3	6	4	4

The eggs are generally white or pearly, club-shaped or tooth-shaped, and about 1.5 millimeters long by 0.3 millimeter wide at the maximum diameter. The largest egg found locally is that of *Thelia bimaculata*, which averages 2.6 millimeters in length and 0.6 millimeter in diameter; the smallest is that of *Publilia concava*, which measures 0.7 millimeter in length and 0.17 millimeter in diameter. The egg may be smooth or sculptured, the base usually being rounded and the tip pointed. In the eggs of most species a distinct neck is visible, often grooved. The chorion is usually vitreous. The micropyle in most cases is oval, opening tangential to the longitudinal axis. The cap is comparatively large, and before hatching becomes swollen and wrinkled. The lateral margins of the egg are curved, one side often being more convex than the other. Just before the eggs hatch they become slightly larger.

DURATION OF EGG STAGE

Since most of the species winter over in the egg stage, the period of incubation for these eggs cannot be exactly determined. For those species that show several broods a year, however, it is possible to determine the duration of the egg stage. This has been noted both in the field and in the laboratory. The average length of this period is approximately twenty days. Miss Branch (1913:84) has found that nine days represents the egg stage of *Entylia sinuata*. No local species has shown so short a period. Wildermuth (1915:349) reports cases in which only twelve days are required for incubation of *Stictocephala festina*, but gives the average as twenty-two days, with a maximum of forty-one days, depending on the prevailing temperature. Even more remarkable is the record of Mr. Gibson, in Greenwood, Mississippi, who noted an incubation of the same species in four days (Wildermuth, 1915:349–350). In the course of this study no experiments with artificial temperatures in respect to temperature variation in the length of the egg stage have been made, but, as will be noted under the subject of ecology, the natural climatic conditions have had a decided influence on the incubation of the egg and the development of the nymphs.

DATES OF HATCHING

The time of hatching of the eggs depends largely on climatic conditions, being much later in some years than in others, but considerable variation is found in eggs of the same species in the same season. A difference of two weeks between the appearance of the first and the last records in the field is not unusual. It is presumed that in such cases the eggs hatching first were those deposited earliest in the preceding fall, but this is not known to be true.

Even in the same egg mass the eggs do not all hatch at the same time, a difference of nearly a week between the first and the last having been observed in some cases. The explanation of this variance is not forthcoming, since of course the eggs may be assumed to have been laid at one oviposition and the environmental conditions were identical for all.

MECHANICS OF HATCHING

The mechanics of the process of hatching is practically the same for all species studied. A few days before hatching, the egg appears somewhat

swollen. This is followed by a cracking of the chorion about the neck and the upper end — that is, the end that leaves the ovipositor last and is nearest the surface of the host. Some days may elapse after the first splitting of the egg before the insect emerges. Finally the cap is forced upward and the head of the nymph appears. The head is quickly followed by the thorax and part of the abdomen. The nymph then appears to rest for a few minutes, after which the legs are slowly withdrawn in order, beginning with the first pair. At the same time the dorsal spines become protruded, while the insect is still held by the posterior end of the abdomen inside the shell. Finally this posterior end of the abdomen is pulled out, and the nymph creeps a very short distance away from the old shell and again rests. The entire time required for the emergence, from the time the head is first seen until the process is completed, is usually about half an hour. Hodgkiss (1910:88) has timed the process as from seven to nine minutes, but this speed has not been equaled by any of the local forms in the field. Wildermuth reports, for two specimens of *Stictocephala festina* timed, a period of eighteen and twenty-eight minutes, respectively.

INSTARS

All the species studied show five nymphal instars. Miss Branch (1913:84) reports only four instars for *Entylia sinuata*, but the nearest local relative of the species, *Entylia bactriana*, shows the usual five. Riley (1873) likewise observed that *Ceresa taurina* molted but four times before reaching maturity. His report called the species *Ceresa bubalus*, but it is now known that *Ceresa taurina* was the form he had in mind. This species is abundant in the Cayuga Lake Basin, and in all cases studied showed five instars. Each of the five instars is distinct enough to be recognized, and displays characters sufficient not only for the recognition of the species but also for the identification of the particular stage of development that it represents.

In the first instar the nymph is of course very small, not greatly exceeding in length the egg from which it hatched, very light-colored, and extremely soft-bodied. Most nymphs have characteristic dorsal spines on thorax and abdomen. In the first stage these spines are much inclined to be complex and branched, and are numerous on the head and the thorax with often more than one row on the abdomen. The head is very large, out of all proportion to the body, and the legs are feeble. The eyes

are likely to be prominent, and the ocelli and the antennae not distinguishable. If the species is a pubescent one the hairs are usually not developed in this instar. No wing pads are visible from an external view and the abdomen is somewhat attenuated. The pronotum is not developed and the prothorax is about equal in size to the other thoracic segments.

In the second instar the size is usually doubled and the entire insect is much darker in appearance. The prothorax is inclined to be swollen dorsally but no distinguishing protuberance of the pronotum is apparent. No wing pads are visible. The head is more normal in comparative size and the eyes are not so prominent. The ocelli may usually be distinguished and likewise the antennae. The spines are still very complex and branched but seldom appear on the head. The anal segment of the abdomen is generally prolonged and the entire body is stouter.

In the third instar the characteristic enlargement of the pronotum begins to appear and the wing pads are evident. The prothorax is much larger than the other two thoracic segments. The head is normal in size and the eyes are usually not prominent. The antennae are plainly to be seen. The spines have lost much of their complexity and are much shorter and less branched. In this stage the spines of the head and the thorax are often entirely wanting and the whole body develops pubescence. The anal segment of the abdomen is still much enlarged and the anal tube is prominent.

In the fourth instar the pronotal enlargement is prominent, the posterior process usually covering the mesothorax. The wing pads are large and well developed, usually extending posteriorly as far as the third abdominal segment. The head is reduced in comparative size, the ocelli are prominent and the antennae are normal. The spines are much reduced in complexity if not in size. Often they appear as mere stubs or bristles, and are seldom on any other part of the body than the abdomen. The insect has increased much in size and often shows colors characteristic of the adult insect.

The fifth and last instar is usually the longest in duration and is by many authors called the *pupa*, tho by what authority is not clear. The activities of the insect are apparently in no way different from what they were in the preceding stages, and there is certainly no quiescence nor transformation that would justify the name. It is in fact confusing to apply the term *pupal stage* to insects having such a representative

incomplete metamorphosis as do the Membracidae, and in this report the term is discarded. In this instar the nymph attains a size comparable with that of the imago. The pronotal developments are very pronounced and the wing pads are fully formed, usually reaching the fourth abdominal segment. The spines are heavy but generally rather simple. The head is much deflexed or prone, and eyes, ocelli, and antennae are normal. The beak is fully developed, generally extending posteriorly as far as the hind coxae. The legs are strong and stout and the abdomen is swollen. The anal tube is somewhat less prominent than in the preceding stages.

The above descriptions apply of course to the family in general and find many exceptions in various species. On the whole, however, they represent the general development of membracid nymphs. Certain particular characters may be noted as of interst and value in recognition. The development of the pronotum is noteworthy as it usually gives the clue to the species. Since all the local species of which the life history is known have the posterior pronotal process, the gradual extension of this structure is common to all nymphs. The anterior decorations are, however, generally distinct, and, in the last instar at least, the vestigial lateral horns of the Ceresas, the porrect spike of Thelia, the notch of Entylia, and the crest of the Telamonas, are strikingly suggestive.

The peculiar spines which are more or less characteristic of all the nymphs of the family are scarcely less important. Their number, position, arrangement, and type of branching are all guides in the determination of the species and of the nymphal instar. As has been noted, most species show these more abundantly on the head and the thorax in the earlier than in the later instars, and the abdominal bristles are inclined to be more elaborately branched in the first stages than in the last. This is not, however, always the case, for some forms retain these twig-like branched appendages until their last molt and a few have no such bristles in any of their nymphal stages. The shape of the individual spines is of interest — whether straight or curved, branched or simple, long or short, heavy or light; likewise the arrangement — whether singly or in pairs, in regular or irregular rows, opposite or indeterminable.

The coloration of the nymph seems to be of much less value, since many forms show much variation within the species. Size, likewise, should not be taken as a criterion, except perhaps in comparison of instars of the same species.

In general the nymphs of each genus show some character which is more or less distinct. The Ceresas and the Stictocephalas may be known by their bristling, forest-like growth of branched dorsal spines; the Carynotas by the lack of such spines and the crescent-shaped pronotum; Acutalis and Micrutalis by the fact that the abdominal spines lie almost flat against the body; the Telamonas by the very heavy dorsal abdominal teeth which take the place of the spines, and by the evidence of the pronotal crest; Thelia by the porrect horn on the prothorax; Cyrtolobus by the smooth body and the rounded thorax; Ophiderma by the small size, the hairy appearance, and the flattened dorsum; Campylenchia by the broad abdominal median dorsal plates; Entylia by the prominent notch on the pronotum; and Vanduzea by the straight dorsal line and the peculiar anal tube.

The time required for each nymphal instar varies not only for the different species, but also for the nymphs of a single species and even for the individuals in a single egg mass. For this reason the general subject of nymphal periods can be discussed only roughly. In general, however, it may be said that the average for each of the first four instars is about five days and for the fifth instar ten days, making a total of thirty days for the complete period of development from egg to adult. This may be shown for some of the more abundant of the local forms by the following table of averages.

	First instar	Second instar	Third instar	Fourth instar	Fifth instar
Enchenopa binotata	6 days	5 days	6 days	8 days	10 days
Ceresa diceros	7	4	5	5	8
Ceresa bubalus	7	7	7	7	14
Ceresa taurina	8	7	7	10	15
Ceresa borealis	5	11	9	10	12
Stictocephala inermis	9	8	8	9	13
Thelia bimaculata	7	5	6	6	11
Telamona reclivata	10	9	8	7	12
Telamona unicolor	10	6	5	10	14
Telamona ampelopsidis	6	7	10	10	15
Cyrtolobus vau	6	5	5	5	10
Vanduzea arquata	5	3	3	4	8
Entylia bactriana	5	5	5	5	8

The variation between the periods of development of the different species is probably normal and more or less indicative of the requirements for each species concerned.

The variation in one species in different years can probably be explained by climatic conditions, and the same factor may explain the varying periods required for different broods in the same season and even for nymphs from different egg masses hatching at about but not exactly the same time.

The variation in the length of time required for nymphs from a single egg mass is, however, not to be explained on this ground, and yet such variation is very common. The factors entering into the problem are rather numerous. When it is said that all the nymphs from one egg mass do not reach maturity at the same time, it must be remembered that all the eggs from this egg mass may not have hatched at the same time. It has been shown, however, that the nymphs from the eggs first hatched do not always reach maturity before those from the eggs last hatched. Moreover, the nymphs from eggs hatching at the same time do not reach maturity together. Still further, nymphs that have hatched at the same time and reached maturity at the same time have often not kept together during the different molts. For example, the records of two nymphs emerging on the same day showed respectively for the five instars 8–7–7–10–15 and 7–8–8–8–16 days, and transformed into adults on the same afternoon. Such variation can be explained only by individual and physiological differences not evident in the ordinary life-history studies. There is often a difference of as much as two weeks between the dates of maturing of the earliest and the latest individuals from the same egg mass, and as much as one week between individuals from eggs hatching on the same day.

ECDYSIS

There are various types of ecdysis, but seldom is there any variation in this respect within a genus. In most cases the nymph of the last instar fastens itself securely to the underside of a leaf just before its final molt, and the old exuviae may be found in this position for several days after the process has been completed. In some cases only the first pair of legs are thus attached, in others all six legs. Some species do not attach themselves and the old skin falls to the ground as soon as ecdysis is com-

plete; in other species the old nymphal skin hangs to the end of the abdomen of the adult and is carried about for some time after molting.

Just before the last molt the skin dries out and becomes more or less transparent and scaly. Under the microscope it is possible to distinguish regions in which the integument has pulled away from the new skin even before splitting begins.

The splitting occurs down the dorsal line but does not always start at the same place. In most cases the first splitting occurs along the dorsal line of the head; in a considerable number it begins near the thorax, and in a few over the abdomen.

The head generally emerges first, then the thorax, then the legs, and lastly the abdomen. The various segments gradually enlarge as they are freed, and become decidedly swollen within a few minutes following ecdysis. In some species the thorax emerges before the head; in others the head, the thorax, and the abdomen before the legs; and in a few the last pair of legs and the last segments of the abdomen remain longest in the old skin. These rather distinct types of ecdysis may be illustrated by the common species *Vanduzea arquata*, *Thelia bimaculata*, and *Ceresa borealis*.

In *Vanduzea arquata* the nymph attaches itself securely by the first pair of legs to the underside of a leaf. The splitting begins over the thorax and the dorsal part of the thorax emerges first; this is followed by the head, then the legs, and then the abdomen. The old skin is very perfect and remains attached to the leaf.

In *Thelia bimaculata* the insect is not attached. The splitting begins over the head and this part of the body emerges first; then the thorax appears and the integument breaks around the coxae and the femora, leaving pieces of old skin attached to the legs for some time after ecdysis is completed; the abdomen is then removed, and lastly the legs. The old skin is very imperfect, being much broken and torn, and drops to the ground after the process is completed.

In *Ceresa borealis* the insect is not attached. The splitting begins over the head and gradually continues over the thorax and the abdomen. The head emerges first, then the thorax, then the first half of the abdomen, then the legs, and then the posterior half of the abdomen. The old skin is very perfect and remains attached to the tip of the abdomen, where it is dragged behind for some time.

The time required for the process is not subject to great variation within a species, but is rather different in various genera and usually ranges from five to forty-five minutes. The least time noted in field records for the process is three minutes, for *Enchenopa binotata*, and the greatest is seventy-five minutes, for *Telamona ampelopsidis*. The average for several common species, as worked out from one or more timed in each case, is as follows:

Enchenopa binotata	6 minutes
Ceresa diceros	10
Ceresa bubalus	11
Ceresa taurina	9
Ceresa borealis	8
Stictocephala inermis	25
Carynota mera	30
Thelia bimaculata	12
Telamona declivata	40
Telamona unicolor	33
Telamona ampelopsidis	28
Smilia camelus	17
Cyrtolobus vau	50
Ophiderma pubescens	8
Vanduzea arquata	10
Entylia bactriana	5

The exuviae, if perfect, may be used for diagnosis and correctly represent the last nymphal stage. Altho the splitting of the integument occurs along the median dorsal line, the spines in this region are seldom injured as the break appears on one side or the other at their bases. Even in broken specimens the injuries are usually around the bases of the legs or on the abdomen, and do not interfere with the characters necessary for recognition purposes.

The nymphs are active but they do not jump as do the adults. They are prone to hide themselves in crevices in the bark and in the axils of leaves, where their coloration renders them very inconspicuous. If disturbed they often creep around to the opposite side of the twig and are able to run fairly rapidly when in the later instars. They often have the habit of flattening themselves close to the twig if molested and remain without movement even when touched. During ecdysis they are of course comparatively helpless and may be studied with great ease.

The newly emerged adults are lighter in color than the normal hue of the species, and very soft-bodied. The exoskeleton becomes hardened, however, within a couple of hours and the normal colors appear in twenty-

four hours. If the insects are injured during this period the injury becomes permanent and the mutilation may appear as a grotesque twist or bend in the hardened pronotum. It is not unlikely that such injured specimens have given rise to certain new species and varieties, the descriptions of which have been based on apparently new pronotal characters.

RELATION OF NYMPHS AND ADULTS TO HOSTS

After reaching the adult stage the insect often moves to a different host from that on which the eggs were laid. In fact such migration may take place during the last or the next to the last nymphal instar. In some cases a clear distinction between the host used for oviposition and that used as a food plant may be made; in other cases the insect spends its entire life on one plant which serves both as food and as an egg host. In the latter case both nymphs and adults may be taken together, and apparently they lead a more or less gregarious existence.

BROODS

Most of the local species have but one brood a year. A few exceptions, however, may be noted. *Campylenchia latipes* normally has two broods and some of the adults of the second brood winter over in that stage. *Ceresa borealis* has two broods, but the adults of the second brood die after depositing their eggs. *Stictocephala inermis* is believed to have two broods, at least in certain years when the seasons are favorable. Wildermuth (1915:357) reports four generations for the closely related species *S. festina* in Arizona, where no hibernation is required. *Cyrtolobus vau* has two broods, and in some seasons three if warm weather continues late in the fall. It may be that in some instances the adults of the last brood of this species may survive the winter. *Vanduzea arquata* may have four broods during the year, three from the summer and one from the winter eggs. This is the largest number of generations in a year for any of the species studied. *Entylia bactriana* has two, and possibly three, broods a year. Miss Branch (1913:84) estimates six or seven broods a year for the closely related species *Entylia sinuata* in Kansas.

The number of broods in a year is, however, very largely dependent on the weather conditions of the seasons concerned. It is very probable that a decided variation in number of broods may occur in different parts of the country, and that the data reported for the Cayuga Lake

Basin will be worthless when applied to other localities. As is noted later under the subject of ecology, even the variations found in local weather conditions have had their effect on the number of generations in a season, and it is reasonable to conclude that the number is not constant over a wide territory.

Even locally the estimation of the number of broods for the great majority of species must be based only on observations made in the field, since it is impracticable to maintain in the laboratory or the insectary the necessary hosts for oviposition and feeding thruout the year. Furthermore, the overlapping of the stages of nymphal development, and the consequent prolongation of mating periods after maturity with the resulting variation in periods of oviposition, make it impossible to state the exact number of days that may be assigned to each generation.

In the case of species having two or more generations a year, such as *Vanduzea arquata* and *Entylia bactriana*, the field records are made with great difficulty as it often happens that nymphs of all stages and adults of all ages may be collected from one host practically thruout the entire summer.

WINTERING OVER

Careful search has been made for evidence that membracids winter over in any other form than the egg stage, which is certainly the normal method. The results seem to show that *Entylia bactriana* and *Publilia concava* pass the winter as adults, and that occasionally *Cyrtolobus vau* may do likewise. These conclusions have been based on the fact that imagoes of these species have been found hibernating in soil and forest litter during the winter months and have become active on being brought into the laboratory, and the fact that adults have been collected in the spring at dates so early as to preclude the possibility of nymphal development. The usual methods of investigation have been to sift the earth and débris beneath the plants which the insects are known to inhabit; to make examinations of the leaves and the bark of such hosts during the winter; and to make early spring and late fall collections in order to note the stages taken.

It would appear from such investigations that the above-named species are the only ones that survive locally in the imago stage. If any others have similar habits they have not yet been discovered.

No evidence has been found to indicate that nymphs of any stage survive the winter months. This is not surprising when the life habits of the insects and the severity of the local winters are considered.

It may be that even in the case of species known to pass the winter in the egg stage some adults may survive likewise; but as a general rule it has been taken for granted that if winter eggs are commonly found the species depends on this method of hibernation for existence.

LIFE CYCLE

Summarizing in a general way the usual life history of the local species, the following outline may be considered correct:

Eggs: Laid in fall, hatch in early spring.
Nymphs: Emerge about the middle of May and require about six weeks to reach maturity.
Adults: Are common about July 1 and persist thruout summer and fall.
Mating: Takes place the first week after emergence.
Oviposition: Occurs within a week after mating.
Broods: Usually one but sometimes more, dependent on weather conditions.

For a single individual the life cycle would be somewhat as follows:

Egg stage:	From September to middle of May		$8\frac{1}{2}$ months
Nymph:	First instar	1 week	
	Second instar	1 week	
	Third instar	1 week	
	Fourth instar	1 week	
	Fifth instar	2 weeks	
	Total — from middle of May to July		$1\frac{1}{2}$ months
Adult:	From July to October (inclusive)		4 months
Entire life			14 months

LOCALITIES FOR COLLECTING

The following table has been prepared to show the best collecting grounds in the basin for the various species as shown by the collecting in recent years. For each species are given the station that has yielded the species most abundantly, the dates of the appearance in largest numbers of both nymphs and adults, the hosts on which the species has most commonly been taken, and notes as to the relative abundance of the forms

in question. The dates are to be considered as inclusive. It is believed that this table will indicate the most favorable localities in which to search for the local forms of Membracidae and may prove an aid to the student in this respect.

Species	Stations	Nymphs	Adults	Hosts	Remarks
1. *Microcentrus caryae*	J, K, N	July 1–15	August	Hickory	Fairly common
2. *Campylenchia latipes*	D, H	June 10–20	July–August	Grass	Common
3. *Enchenopa binotata*	A, B, L	July–August	August September	Locust, butternut	Very common
4. *Ceresa diceros*	B, P	July	August–September	Black elder	Common
5. *Ceresa bubalus*	All	May 1–15	June–September	Sweet clover	Common
6. *Ceresa taurina*	All	May	July–September	Apple	Common
7. *Ceresa constans*	A, D	No record	August 25	Locust	Fairly common
8. *Ceresa Palmeri*	J	July 1	August 20	Hickory	Rather rare
9. *Ceresa borealis*	L, N	May	June–July	Raspberry	Very common
10. *Ceresa basalis*	C, P	July 25	September 1	Rose	Common
11. *Stictocephala inermis*	D, I	June 1	August 12	Sweet clover	Common
12. *Stictocephala lutea*	A	Not known	August 20	Oak	Fairly common
13. *Acutalis tartarea*	Unknown	No record	July 20	No record	Very rare
14. *Micrutalis dorsalis*	Unknown	No record	August 3–13	No record	Rare
15. *Micrutalis calva*	Q	No record	August 15	Locust	Rare
16. *Carynota mera*	M, N, O, P	July 20	August 5	Hickory, butternut	Common
17. *Carynota porphyrea*	P, Q	No record	August 13	White oak	Scarce
18. *Thelia bimaculata*	All	June–September	August–September	Locust	Very abundant
19. *Glossonotus acuminatus*	N	No record	August 11–13	White oak	Very rare
20. *Glossonotus univittatus*	J	No record	August 21	Hazelnut	Extremely rare
21. *Glossonotus crataegi*	J	No record	August 14	Hawthorn	Rare
22. *Heliria scalaris*	I	No record	August 13	Unknown	Rare
23. *Telamona declivata*	Unknown	No record	July 12	Unknown	Very rare
24. *Telamona pyramidata*	N	No record	July 11	Chestnut oak	Rare
25. *Telamona barbata*	B	No record	June 13	White oak	Rare
26. *Telamona obsoleta*	Q	No record	August	Oak	Rare
27. *Telamona Westcotti*	Unknown	No record	June 23	No record	Very rare
28. *Telamona reclivata*	I	July 1	August 10–20	Basswood	Very common
29. *Telamona monticola*	K, O	July 1–10	September 1	Oak	Questionable species
30. *Telamona querci*	R	June 25	August 6–25	Oaks	Abundant
31. *Telamona ampelopsidis*	D, H, R	June 10–30	July–August	Virginia creeper	Very abundant
32. *Telamona tristis*	J, R	No record	July 20	Hazelnut	Rare
33. *Telamona concava*	Unknown	No record	August 30	Unknown	Very rare
34. *Telamona projecta*	Unknown	No record	No record	Unknown	Extremely rare
35. *Telamona unicolor*	O	May 15–30	August–September	Hickory	Common in southern part of basin
36. *Telamona pruinosa*	Q	June 15–30	August 1–15	Sycamore	Rare
37. *Telamona decorata*	I	July 1	August 15	Linden	Common
38. *Archasia Belfragei*	A, B, C	No record	July 15–30	Locust	Rather common
39. *Smilia camelus*	A, E	May	June 15–July 15	Locust	Common
40. *Cyrtolobus ovatus*	T	No record	July 12	Grass	Very rare
41. *Cyrtolobus fuliginosus*	L	No record	June 20–July 10	White oak	Common
42. *Cyrtolobus muticus*	Unknown	No record	June 14–27	No record	Very rare
43. *Cyrtolobus tuberosus*	O, P	April 15–May 15	June 15–30	Oaks	Very common
44. *Cyrtolobus discoidalis*	Unknown	No record	June 30	Unknown	Very rare
45. *Cyrtolobus cinctus*	D, N	No record	July 1	White oak	Fairly common
46. *Cyrtolobus vau*	All	June 1–15	July–August	Oaks	Extremely abundant
47. *Cyrtolobus intermedius*	B, C	No record	July 18	Unknown	Not common
48. *Cyrtolobus cinereus*	B	No record	July 3	Oak	Rare

Species	Stations	Nymphs	Adults	Hosts	Remarks
49. *Cyrtolobus fuscipennis*	B	Unknown	July 1	Oak	Very rare
50. *Atymna castaneae*	All	June 15–30	July 1–15	Chestnut	Abundant
51. *Atymna querci*	M, S, V	June	July 1–10	Oak	Very common
52. *Atymna inornata*	F, V	No record	July–August	Oaks	Not common
53. *Xantholobus trilineatus*	O, P	June 1	July 1–10	Oaks	Common
54. *Xantholobus lateralis*	Unknown	No record	June 30	Unknown	Very rare
55. *Ophiderma salamandra*	A, B, Q	May	June 15–July 10	Oaks	Very common
56. *Ophiderma pubescens*	All	April 20	June 10–30	White oak	Abundant
57. *Ophiderma flavicephala*	J	No record	June 1–10	Unknown	Rare
58. *Ophiderma flava*	L	No record	June 5–20	Unknown	Rare
59. *Vanduzea arquata*	All	Entire summer	Entire summer	Locust	Commonest species in basin
60. *Entylia bactriana*	J	Entire summer	Entire summer	Thistle	Very abundant
61. *Publilia concava*	V	No record	June–September	Goldenrod	Rare

HOSTS

The Membracidae have shown themselves to be excellent botanists and in most cases confine themselves to very definite host plants both for feeding and for oviposition. In many cases the association between the membracid and the host is so characteristic that a knowledge of the one is sufficient for recognition of the other. This is particularly true for such species as *Telamona ampelopsidis,* which not only confine themselves to a single host but are the only species ever found on the host. A large number of species of the family have been named to indicate such associations, and the local forms with such specific names as *querci, castaneae, crataegi, ampelopsidis,* and the like, are representative of such species.

The host plants concerned may be divided into four rather well-defined groups of plants. The most important of these groups is represented by the Amentiferae, including such nut-bearing trees as oak, hickory, butternut, chestnut, beech, and hazelnut; of hardly less importance are the legumes, of which the local forms of locust, sweet clover, alfalfa, and red clover are favorite hosts for many species of membracids; the Rosaceae in general, but particularly apple, pear, berries, and cultivated roses, represent the third group; while the fourth includes a large number of succulent composites such as annual asters, sunflower, daisy, joe-pye weed and thistle. Practically every plant that has been recorded as a host plant for any species of Membracidae may be included in one of these four groups.

The following tables are offered to show the combinations of plants and species as represented in the basin. Only those hosts on which the membracids have actually been taken while feeding or ovipositing are included, and the list is therefore purely local. The literature referring to various species occasionally mentions other hosts on which the forms have been taken in various parts of the country. In all cases such hosts, if represented in the local flora, have been carefully examined for verification of the record, but the name is not here included unless such verification has been established. No attempt has been made in this list to distinguish between the hosts sought for oviposition and those preferred for feeding, since the former have been separately discussed under the life history notes.

HOST — SPECIES

White oak (*Quercus alba* L.)
- *Microcentrus caryae*
- *Ceresa bubalus*
- *Ceresa diceros*
- *Ceresa taurina*
- *Ceresa borealis*
- *Stictocephala lutea*
- *Carynota mera*
- *Carynota porphyrea*
- *Glossonotus acuminatus*
- *Telamona barbata*
- *Telamona obsoleta*
- *Telamona querci*
- *Telamona tristis*
- *Archasia Belfragei*
- *Cyrtolobus fuliginosus*
- *Cyrtolobus tuberosus*
- *Cyrtolobus cinctus*
- *Cyrtolobus vau*
- *Atymna querci*
- *Atymna inornata*
- *Xantholobus trilineatus*
- *Ophiderma salamandra*
- *Ophiderma pubescens*

Chestnut oak (*Quercus Prinus* L.)
- *Microcentrus caryae*
- *Ceresa borealis*
- *Carynota mera*
- *Telamona pyramidata*
- *Telamona obsoleta*
- *Telamona querci*
- *Smilia camelus*
- *Cyrtolobus vau*
- *Atymna querci*
- *Xantholobus trilineatus*
- *Ophiderma salamandra*

Red oak (*Quercus rubra* L.)
- *Ceresa bubalus*
- *Ceresa borealis*
- *Cyrtolobus vau*
- *Telamona decorata*

Scarlet oak (*Quercus coccinea* Muench.)
- *Ceresa diceros*
- *Cyrtolobus tuberosus*
- *Cyrtolobus vau*

Locust (*Robinia pseudacacia* L.)
- *Enchenopa binotata*
- *Ceresa diceros*
- *Ceresa bubalus*
- *Ceresa taurina*
- *Ceresa constans*
- *Ceresa borealis*
- *Micrutalis calva*
- *Thelia bimaculata*
- *Archasia Belfragei*
- *Smilia camelus*
- *Vanduzea arquata*

Hickory (*Carya ovata* Koch)
- *Microcentrus caryae*
- *Enchenopa binotata*
- *Ceresa bubalus*
- *Ceresa taurina*
- *Ceresa Palmeri*
- *Ceresa borealis*
- *Carynota mera*
- *Telamona unicolor*
- *Cyrtolobus tuberosus*

Pignut (*Carya cordiformis* Koch)
- *Ceresa bubalus*
- *Ceresa borealis*

Elm (*Ulmus americana* L.)
Ceresa bubalus

Willow (*Salix nigra* Marsh.)
Ceresa bubalus
Ceresa borealis

Quince (cultivated)
Glossonotus crataegi

Hawthorn (sp.)
Glossonotus crataegi

Crab apple (cultivated)
Glossonotus crataegi

Sumac (*Rhus glabra* L.)
Ceresa bubalus

Hazelnut (*Corylus americana* Walt.)
Ceresa bubalus
Ceresa taurina
Glossonotus univittatus

Black elder (*Sambucus canadensis* L.)
Ceresa diceros
Ceresa bubalus
Ceresa borealis

Red elder (*Sambucus racemosa* L.)
Ceresa bubalus

Rose (cultivated)
Ceresa basalis

Sunflower (cultivated)
Entylia bactriana

Wild grape (*Vitis aestivalis* Michx.)
Enchenopa binotata
Ceresa borealis

Bittersweet (*Celastrus scandens* L.)
Enchenopa binotata
Ceresa taurina

Blackberry (cultivated)
Ceresa diceros
Ceresa taurina

Raspberry (cultivated)
Ceresa taurina
Ceresa borealis

Witch-hazel (*Hamamelis virginiana* L.)
Ceresa taurina
Telamona tristis

Virginia creeper (*Psedera quinquefolia* L.)
Telamona ampelopsidis

Daisy (*Chrysanthemum leucanthemum* L.)
Enchenopa binotata
Campylenchia latipes
Stictocephala lutea

Joe-pye weed (*Eupatorium purpureum* L.)
Enchenopa binotata
Campylenchia latipes
Entylia bactriana

Aster (*Aster novae-angliae* L.)
Campylenchia latipes
Ceresa bubalus

Alfalfa (cultivated)
Campylenchia latipes

Prickly lettuce (*Lactuca scariola* L.)
Campylenchia latipes

Wild carrot (*Daucus carota* L.)
Campylenchia latipes

Sweet clover (*Melilotus alba* Desr.)
Ceresa diceros
Ceresa bubalus
Ceresa taurina
Stictocephala inermis

Potato (cultivated)
Ceresa bubalus
Ceresa taurina

Dahlia (cultivated)
Ceresa taurina

Bluegrass (cultivated)
Ceresa taurina

Timothy (cultivated)
Stictocephala inermis

Red clover (cultivated)
Stictocephala inermis

Thistle (all species found locally)
Entylia bactriana

Goldenrod (*Solidago canadensis* L.)
Publilia concava

Butternut (*Juglans cinerea* L.)
Enchenopa binotata
Ceresa diceros
Ceresa bubalus
Stictocephala inermis
Carynota mera
Telamona unicolor

Walnut (*Juglans nigra* L.) (Uncommon in the basin)
Telamona unicolor

Chestnut (*Castanea dentata* Borkh.)
Atymna castaneae

Sycamore (*Platanus occidentalis* L.)
Enchenopa binotata
Ceresa diceros
Ceresa bubalus
Ceresa borealis
Telamona pruinosa

Basswood (*Tilia americana* L.)
- *Telamona barbata*
- *Telamona reclivata*
- *Telamona tristis*
- *Telamona unicolor*
- *Telamona decorata*

Dogwood (*Cornus florida* L.)
- *Enchenopa binotata*

Poplar (*Populus deltoides* Marsh.)
- *Ceresa bubalus*

Pear (cultivated)
- *Ceresa bubalus*
- *Ceresa taurina*
- *Ceresa borealis*

Apple (cultivated)
- *Ceresa taurina*
- *Ceresa bubalus*
- *Stictocephala inermis*
- *Ceresa borealis*

Skunk cabbage (*Symplocarpus foetidus* L.)
- *Publilia concava*

SPECIES — HOST

1. *Microcentrus caryae* — Hickory, oak
2. *Campylenchia latipes* — Aster, daisy, joe-pye weed, alfalfa, prickly lettuce, wild carrot
3. *Enchenopa binotata* — Locust, wild grape, bittersweet, hickory, sycamore, butternut, dogwood, daisy, joe-pye weed
4. *Ceresa diceros* — Locust, elder, oak, sycamore, sweet clover, blackberry, butternut
5. *Ceresa bubalus* — Sycamore, aster, poplar, potato, butternut, hazelnut, pear, sumac, oak, locust, elm, willow, elder, sweet clover, hickory, pignut, apple
6. *Ceresa taurina* — Raspberry, hickory, potato, blackberry, dahlia, hazelnut, locust, witch-hazel, bluegrass, oak, pear, apple, sweet clover, bittersweet
7. *Ceresa constans* — Locust
8. *Ceresa Palmeri* — Young hickory
9. *Ceresa borealis* — Wild grape, locust, elder, willow, oak, hickory, pignut, raspberry, sycamore, apple, pear
10. *Ceresa basalis* — Rose
11. *Stictocephala inermis* — Sweet clover, apple, timothy, red clover
12. *Stictocephala lutea* — Oak, daisy
13. *Acutalis tartarea* — Host unknown
14. *Micrutalis dorsalis* — Host unknown
15. *Micrutalis calva* — Locust
16. *Carynota mera* — Oak, hickory, butternut
17. *Carynota porphyrea* — White oak
18. *Thelia bimaculata* — Locust
19. *Glossonotus acuminatus* — White oak
20. *Glossonotus univittatus* — Hazelnut
21. *Glossonotus crataegi* — Hawthorn, crab apple, quince
22. *Heliria scalaris* — Host unknown
23. *Telamona declivata* — Host unknown
24. *Telamona pyramidata* — Chestnut oak
25. *Telamona barbata* — White oak, basswood
26. *Telamona obsoleta* — Various oaks
27. *Telamona Westcotti* — Host unknown
28. *Telamona reclivata* — Basswood
29. *Telamona monticola* — Oaks
30. *Telamona querci* — White oak, chestnut oak
31. *Telamona ampelopsidis* — Virginia creeper
32. *Telamona tristis* — Witch-hazel, basswood, oak, hazelnut
33. *Telamona concava* — Host unknown
34. *Telamona projecta* — Host unknown
35. *Telamona unicolor* — Hickory, butternut, walnut, basswood
36. *Telamona pruinosa* — Sycamore

37. *Telamona decorata* — Red oak, basswood
38. *Archasia Belfragei* — Locust, oak
39. *Smilia camelus* — Locust, oak
40. *Cyrtolobus ovatus* — Grass
41. *Cyrtolobus fuliginosus* — White oak
42. *Cyrtolobus muticus* — Host unknown
43. *Cyrtolobus tuberosus* — White oak, red oak, hickory
44. *Cyrtolobus discoidalis* — Host unknown
45. *Cyrtolobus cinctus* — White oak
46. *Cyrtolobus vau* — White oak, chestnut oak, red oak, scarlet oak
47. *Cyrtolobus intermedius* — Host unknown
48. *Cyrtolobus cinereus* — Oak
49. *Cyrtolobus fuscipennis* — Oak
50. *Atymna castaneae* — Chestnut
51. *Atymna querci* — White oak, chestnut oak
52. *Atymna inornata* — White oak
53. *Xantholobus trilineatus* — Oak
54. *Xantholobus lateralis* — Host unknown
55. *Ophiderma salamandra* — Oak
56. *Ophiderma pubescens* — White oak
57. *Ophiderma flavicephala* — Host unknown
58. *Ophiderma flava* — Host unknown
59. *Vanduzea arquata* — Locust
60. *Entylia bactriana* — Thistle, joe-pye weed, sunflower
61. *Publilia concava* — Goldenrod, skunk cabbage

It is interesting to note that certain species common in many parts of the country and having a wide geographical range shift from one host to another in varied localities. If the favorite host of the species is not represented a close relative is usually chosen. Thus, *Carynota mera*, common on pecan in the South, is found in the Cayuga Lake Basin on hickory.

In other cases the species seems to deliberately change its host even tho an apparently more constant host is abundant. Thus, *Enchenopa binotata*, which in most parts of the United States seems to prefer the hop tree (*Ptelea trifoliata* L.), is locally much more likely to be found on the locust or on the butternut; *Stictocephala inermis*, found in many parts of the country on alfalfa, has in this basin changed to sweet clover for food and to apple and pear for oviposition.

It has been noted that certain species change their hosts during the life cycle, the nymphs migrating from the host on which the eggs were laid to feed on another host and returning to the first for oviposition. These cases have been discussed in the life histories of the separate species, and may be illustrated without further discussion by referring to *Ceresa taurina*, which lays eggs on apple but feeds on aster, and to *Ceresa bubalus*, which lays eggs on elm but feeds on sweet clover.

The literature referring to hosts adopted by Membracidae is not extensive and is widely scattered. The most important contribution to the subject was made by Goding (1893 a) in a published list of food plants of the family; Miss Branch (1913: 113-114) has published a list of the host plants on which the Kansas forms have been taken; Van Duzee (1908 a) mentions the hosts on which a number of species are commonly taken; and various economic papers (Hodgkiss, 1910; Wildermuth, 1915) and life history reports (Matausch, 1910, a and c, and 1912 a; Funkhouser, 1915, b, c, and f) have discussed the hosts of the particular species in question. These publications have, however, been ignored in this study except in so far as the data mentioned have been verified by actual observation as holding true for the Cayuga Lake Basin.

MIGRATIONS

The migration of the Membracidae is apparently very slow both as regards change of locality and change of host plants. So far as local records show there is no reason to believe that any species has changed its habitat to any great extent during the years in which this study has been in progress. The same forms may be found in the same locality year after year while neighboring localities offering the same natural conditions remain unentered. Records for other parts of the State and for the country in general would seem to indicate that this slowness of migration is characteristic of the family.

The same is true in regard to migrations from one plant to another. It often happens that one tree may be literally covered with individuals of a species, while another tree of the same kind, in close proximity to the first, may be unmolested; and these conditions may be noted season after season.

The reasons for such reluctance in seeking new localities and new hosts are not evident. The insects fly well for short distances and should be able without difficulty to spread over a considerable area in a season provided the desired host is abundant thruout the area. This, however, appears not to be the case and probably explains why the Membracidae are not often noted as economic pests.

The migration of the nymph from the hosts on which the eggs are laid to the feeding plant, in cases in which such movement is part of the life history, is regular and definite. The distance covered, however, from the

one plant to the other is never great. Usually the nymph merely falls or creeps to the ground and finds a satisfactory food plant under the tree on which it was hatched.

The adults avoid flights of any distance, and if disturbed they generally leave the twig with a quick leap, fly rapidly in a short circle, and return to the plant from which they were driven. Even in a series of trees close together, all of the same kind and all inhabited by membracids of the same species, it is unusual to see the insect fly from one tree to another.

The greatest amount of movement noted in the field is found in fields of sweet clover or alfalfa, in which the insects may fly erratically about when disturbed.

HABITS

The Membracidae are sun-loving insects and are found oftenest on plants growing in open fields, along roadsides, and at the edges of timber. They are seldom seen in shady woods. In practically all cases they seem to prefer the younger plants; the tree-inhabiting species are most likely to be found on saplings, or, if on older trees, on the youngest twigs. Most forms stay close to the ground, and even those species that live on trees of considerable size are usually on branches not over twenty feet from the ground.

The adults have the interesting habit of ranging themselves in rows on the branches (Plate XLI, 1), often thirty or forty individuals placing themselves so close together that their bodies almost touch one another and remaining in this position for hours at a time. In the large majority of cases the adult rests with its head pointing toward the base of the branch, or pointing downward if it is on the trunk. By actual count over nine-tenths of the individuals noted in a test to establish this fact were found in this position (Plate XLI, 2). Whether this characteristic attitude is assumed in order to increase their resemblance to the thorns, twigs, or irregularities of growth of their host would be a matter of conjecture. The nymphs are usually found tightly flattened in crevices of the bark or pressed closely in the axil of a leaf or the crotch of a twig. In most cases the coloration of the nymphs is such that they are not easily seen when in such positions. The protective resemblance in many cases is strengthened by the presence of the dorsal spines of the immature insect, which carry out leaf and bark outlines to an extent which conduces to a most effective concealment.

Membracids are generally the most active during the warmest parts of the day. Feeding, mating, oviposition, and flight have all been observed oftenest during the hours from eleven o'clock in the morning until four in the afternoon, and more activity is shown on extremely warm days than on cool ones. This may be due to the fact that the bird enemies of the insects are less numerous during the heat of the day, but such an explanation can be advanced only as a theory. In the case of certain species attended by ants it has been thought that the activity of the membracids during the hours mentioned might be due to the activity of the ants at that time. This, however, may be the converse of the true reason, since it may be that the ants are influenced by the membracids, and in either case there is no apparent reason why either insect should show increased activity at definite periods.

When at rest the insect generally chooses the underside of the first- or second-year growth of trees or the upright stem of herbaceous plants. The legs are spread rather widely apart, allowing the abdomen to almost touch the host but keeping the hind legs in a suitable position for springing. This position may be held for long periods of time, often for hours together, tho actual records are not available owing to the fact that the patience of the writer in timing the resting period of an individual has never equaled the pleasure of the insect. Some species have the habit of moving spirally around the twig, the movement being very slow but sufficient to accomplish a complete circuit of the twig in an afternoon. It has been thought that this is done in an attempt to keep in the sunlight as the sun moves across the sky, but this again is merely a conjecture.

If approached, the insect usually moves around to the opposite side of the twig or stem and makes no attempt to fly except as a last resort in escaping. A slowly approaching object is not readily noticed, and the insect may be touched with the finger before it moves if care is taken to make the movement of the hand very slow and deliberate; a sharp, quick movement in the direction of the insect, on the other hand, results in its immediate flight. Few membracids respond quickly to stimuli of light or heat; the light from a mirror or the condensed rays of the sun as projected thru a lens have little effect on the resting insect if no other stimuli are present. Rain causes the membracid to move to the underside of the stem or leaf, but a strong wind merely causes it to cling more tightly to its host without a change of position.

PLATE XLI

1, Resting positions of *Glossonotus crataegi* Fitch
2, Characteristic positions of membracids, close together with heads pointing downward

(Photographs by H. H. Knight)

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PLATE XLI

In feeding, the insects display no peculiarities and the process is a leisurely one. The beak of the membracid is well fitted for piercing, being strong and heavy and fitted with bristle-like mandibular and maxillary setae as described in the discussion of the external anatomy. Both nymphs and adults have little difficulty in forcing the beak into the young stems and the petioles of the leaves, the parts of the plants on which they most commonly feed. It is doubtful whether in all cases the labrum or the labium actually enters the tissue, since it seems possible for the insect to make a sufficient puncture with the setae alone. A few species, notably *Entylia bactriana*, *Enchenopa binotata*, and *Atymna castaneae*, have been observed feeding on the blades of leaves, but this is unusual. Feeding may be observed at almost any hour of the day, depending on the species observed, but the most favored time appears to be the middle of the afternoon. Very little energy is displayed in the feeding movements. The insects remain in one spot for a long time, seeming to find an inexhaustible supply of sap at each insertion of the mouth parts, and they show little disposition to seek new feeding places. So deeply and firmly is the beak sometimes buried in the tissue of the host, and so absorbed do the insects appear to be while obtaining food, that often the mouth parts are broken off in collecting and are left in the stem or leaf when the specimen is captured.

The process of feeding is in some species accompanied by the close attendance of ants. It is presumed that the presence of the ants is to be explained by their well-known habits of seeking the honeydew secreted by the membracids. A large number of observations, however, have suggested that there may possibly be another reason for the presence of the ants at this time. In many instances the ants have been found grouped about the head of the membracid, as tho sharing the sap drawn from the stem. Whether or not the ant would be able to make use of such sap is not known, but the phenomenon has been noticed so many times that it seems unreasonable to believe it accidental. Be that as it may, the membracids seem in no way disturbed by the attention of the ants, and continue the feeding process without noticing their presence.

A study of the locomotion of the Membracidae does not justify the use of the term *tree hopper* as applied to the family. Of the three methods of locomotion — flying, walking, and jumping — the last is certainly the least used. The structure of the wings and of the legs has been discussed in

previous paragraphs of this study, so that here only the general methods of locomotion need to be mentioned.

The insects fly well for short distances, with a sharp, whirring flight which in most cases is too rapid and too erratic to be followed by the eye. The flights, however, are seldom sustained for any great distance. The longest measured flight of any of the local species was made by a female of *Telamona unicolor*, which flew fifty yards from one tree to another in a rather irregular course, swinging for several feet from one side to the other of a straight line in the flight. Specimens of *Atymna castaneae* have been taken about electric lights, and it is evident that this species has the power of remaining on the wing for some little time. Since the membracids have large, powerful, well-developed wings, there seems to be no reason why they should not be capable of long, sustained flight unless they are handicapped by the weight and size of the over-developed pronotum. Buckton (1903:207) has called attention to the fact that the Membracidae, in spite of their abnormal pronotal structures, seem to have no difficulty in locomotion, and states on the authority of Mickeljohn that even the species *Bocydium globulare*, which is one of the most bizarre of the tropical forms, " flitted from one shrub to another without difficulty or apparent laboured flight." The fact remains, however, that even the local forms, which are far less embarrassed by grotesque appendages than are the exotic species, are unable to handle themselves in a creditable fashion tho the mechanism and development of their wings are excellent. It seems very reasonable to conclude, therefore, that the shape, size, and weight of the enormous pronotum proves more of a handicap to the insects than has been supposed. Certainly the Membracidae are far inferior to the closely related families Cicadidae, Fulgoridae, Jassidae, and Cercopidae in the matter of flight.

In the matter of jumping, the Membracidae seem to use this method of locomotion only when leaving the twig for flight. The insect leaves its support with a quick snap, which is apparently accomplished by means of the powerful hind legs tho the movement is entirely too rapid to be diagnosed by observation. The spring from the support on which the insect has rested seems to carry it for some little distance before the wings are spread. There is, however, no true leaping, or hopping, from twig to twig or from leaf to leaf in any species that has been studied in the field.

The commonest method of locomotion is merely walking about over the host. In this process all three pairs of legs seem to be equally functional. The movement is generally slow and deliberate, but when disturbed the insect is able to scramble rapidly around the twig in a rather awkward and amusing fashion. Both nymphs and adults adopt this method as the ordinary means of progress. The nymphs, of course, are unable to fly and in no case has a nymph been seen to attempt anything resembling a leap.

At this point in the discussion of habits it may be well to mention the subject of care of the young, or maternal affection, which has been given rather general circulation in connection with the Membracidae. The theory apparently originated in a report by Miss Murtfeldt (1887) which has been given wide credence and has often been quoted (for example, by Kirkaldy, 1906). Miss Murtfeldt describes the finding of an egg cluster of *Entylia sinuata,* with a female on the leaf, and expresses surprise that the insect did not fly away when touched but remained on the leaf while the latter was carried to the house and later after the eggs had hatched. The significant statement is made, however, regarding the female insect that " although I would not assert that she made any demonstrations of affection, she certainly seemed to enjoy having them [the nymphs] around her." This appears to be the total evidence for belief in the maternal solicitude which is attributed to the Membracidae. The truth is that the species in question is one of the most sluggish of all the membracids, and the most persistent in clinging to the host plant. The writer has often carried a thistle covered with Entylias for several miles along a country road without dislodging the specimens. Moreover, when an attempt is made to take the insect from the leaf, the insect not only does not spring off, but actually seems to cling more tightly to the hairy surface of the leaf to escape being captured. The experience of Miss Murtfeldt is therefore not unusual, nor is the behavior of the membracid in the case at all unnatural, and it is unlikely that the theory of maternal affection as based on her report can be proved. Efforts to substantiate such a theory by observation of local forms have yielded no evidence in its favor. Many forms have the habit of clinging closely to their host plant if disturbed, and this is true whether or not there are eggs or nymphs on the plant with them.

ATTENDANCE BY ANTS

The attendance by ants on various species of Membracidae has often been recorded. Interesting notes have been published on this subject by Belt (1874), Mrs. Rice (1893), Green (1900), Baer (1903), Buckton (1903:262), Poulton (1903), Miss Branch (1913:84), and Lamborn (1914), and attention has been called to the fact by many other authors.

The mutual relationship between these two kinds of insects offers a most interesting field for study and opportunities for delightful and fascinating observations of the insects in their natural habitat. The fact that there are a large number of unsolved problems in connection with this subject makes such study profitable as well as pleasurable, and it is hoped that some of the questions here left unanswered may suggest to students of the family the necessity for further work.

One of the first of these questions is suggested by the fact that some of the species are attended by ants while others are unattended altho there are apparently no physiological or anatomical differences to cause the distinction. Another question arises from the fact that certain species attended locally have never been reported as being attended in other parts of the country, while on the other hand some of the species that are never attended in this basin are always attended in other localities. Again, certain species that the ants ignore in this basin are represented by closely related species in other regions and these exotic forms — often of the same genus and very near systematically — are well attended.

The local species that seem to be always attended by ants are the following: *Thelia bimaculata*, *Telamona ampelopsidis*, *Telamona unicolor*, *Cyrtolobus vau*, *Atymna castaneae*, *Ophiderma pubescens*, *Vanduzea arquata*, *Entylia bactriana*, and *Publilia concava*. It is interesting to note that this list does not include any of the species of the very common genus Ceresa, altho no difference can be detected in the physiology of the forms of this genus as compared with those mentioned, and the nymphs, at least, appear to exude the characteristic anal fluid when disturbed.

The very abundant species *Enchenopa binotata* is not attended by ants locally and there seems to be no record in literature of such attendance. The nymphs of this species show the same extended anal tube as do the nymphs of those species that secrete the fluid which attracts the ants, and they appear in numbers sufficiently large to be easily discovered by the latter if there were any occasion for this mutual relationship. Moreover

PLATE XLII

1, Characteristic positions of *Glossonotus crataegi* Fitch on stem and branch
2, Ants attending *Publilia concava* Say

(Photographs by H. H. Knight)

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PLATE XLII

Baer (1903:306) has described the closely related species *Enchenopa ferruginea* Walk. as being attended by ants, and he has observed this species giving off honeydew.

Nymphs of *Stictocephala inermis* have occasionally been seen attended, but the attendance may have been accidental since the insects have never been seen to give off the anal fluid. Careful studies of other species of this genus in other parts of the United States (cf. Wildermuth, 1915) have failed to record any such phenomena.

Records in literature of *Telamona ampelopsidis* give no mention of the presence of ants, but locally the nymphs of the species, at least, are attended.

The species of ants concerned in the process seem to be common to all the Membracidae. Where two species of Membracidae are abundant on a host at one time, the same kinds of ants may be found attending both species, but the same individual ant has never been observed to go from one species to the other in collecting the secretion. The local species of ants that attend the Membracidae have been determined by Professor W. M. Wheeler as follows: *Formica obscuriventris* Mayr., *Formica exsictoides* Foril, *Camponotus pennsylvanicus* DeGeer, *Crematogaster lineolata* Say, and *Prenolepis imparis* Say. Only those species are recorded that have actually been observed taking the secretion from the membracid. It is possible, therefore, that the list does not include all the ants which take part in the performance, but that other species may be added by future observations. Miss Branch (1913:81) reports *Formica fusca* and *Prenolepis imparis* as being attendant upon *Entylia sinuata*, and Mrs. Rice (1893) describes the same species of membracid as being attended by ants but neglects to mention the species of ants observed. Ball (1915) likewise records ants in attendance upon *Vanduzea vestita* Godg., but does not give the species. In fact, in very few of the cases in which this subject has been mentioned in literature in this country has the determination of the ant concerned been made and reported, altho records giving these data for exotic Membracidae are numerous. In the records available it would appear that the species of Formica are oftenest noted as attending Membracidae. Professor Wheeler, in determining ants taken with South African membracids collected by David Gunn, has written (in correspondence) as follows: "These ants [*Plagiolepsis custodiens* F. Smith] represent in South Africa our species of Formica

and Lasiis and probably derive much of their food from membracids and coccids."

The behavior of both the ants and the membracids is much the same in all the cases studied. The ants stroke their charges with their antennae, whereupon the membracids give off from the anal tube a liquid that issues in bubbles in considerable quantity. The anal tube of the membracid is capable of great evagination, especially in the nymphs, in which it is long and cylindrical and usually tipped with a fringe of fine hairs. The honeydew is eagerly taken from the end of this tube by the ants. In many species the adults as well as the nymphs are sought, and the ants seem to be as attentive to one as to the other but the adults have not been observed to excrete the liquid to the same extent as the nymphs. In general the mutual relationship in the family seems to be much the same as that found between the ants and the aphids. That the ants are well repaid for their attendance can hardly be doubted when their industry around the congregations of Membracidae is noted. In many cases the hiding places of the membracid nymphs are at once betrayed by the swarms of ants present. It is not believed that the ants herd or segregate their charges as in the case of certain insects of the Aphididae, but shelters for membracid nymphs are not uncommon.

The advantage to the membracid is evident by the protection given by the ants, which do not hesitate to bite viciously the fingers of the collector who seeks to remove nymphs or adults from the host. The ants have been observed also to attack spiders and attempt to drive away Reduviidae in the neighborhood of membracid colonies.

It has been suggested in a preceding paragraph that in some cases the ants may take advantage of the punctures made by the membracids to procure sap. The best evidence of this is the fact that ants often remain gathered about the spot where the membracid has fed after the latter has moved away, and apparently they find something there to attract them. This may be explained, of course, by the theory that anal fluid from the membracid has been left on the plant, but it does not account for the fact that the ants are often at the anterior rather than the posterior end of the insect.

The part played by ants in other activities of the Membracidae is a mooted question. Miss Branch (1913:84–85) believes that the attendance of ants is necessary to the molting process in *Entylia sinuata*, and states:

" In my experiments indoors, without the presence of ants, the forms seemed unable to moult successfully and died before reaching maturity. This fact leads me to believe that the ants are necessary factors in the life of an individual membracid." Mrs. Rice (1893) reports that nymphs of the same species reach maturity in two weeks from the date of hatching if ants are present, and in one week if they are undisturbed by ants.

Experiments made in the course of this study give no support to such theories. Membracids of many species have been reared in the field and in the insectary with and without ants, and no difference has been noted in length of the instars or success of the molting process. The species studied by the authors named above, *Entylia sinuata*, is not available locally; but a very closely related species, *Entylia bactriana*, has been reared both in the field under netting and in the laboratory, in each case without the presence of ants, with no noticeable effect on the process of molting.

The feeding habits, likewise, of the Membracidae seem in no way affected by the presence of ants, which often swarm over them in large numbers while feeding is in progress. Both nymphs and adults are apparently oblivious of the presence of their hymenopterous companions, and continue their usual activities with equal serenity whether ants are present or absent.

The liquid sought by the ants has been much discussed in connection with the Aphididae and the Coccidae, and seems in no way different in the Membracidae. It is colorless and transparent, rather heavy, and somewhat sticky. When first exuded it is inclined to be frothy, due no doubt to bubbles of air which emerge with it, but it quickly clears on settling. It is practically tasteless even in comparatively large quantities, and many attempts to distinguish a sweet taste have proved unsuccessful. The term *honeydew*, therefore, commonly applied to the fluid, is hardly a descriptive one. It is very likely, of course, that the liquid may contain sugars not detected by the human tongue, and this would seem to be indicated by the fact that fermentation appears to begin if the substance is left exposed. No chemical analysis of honeydew has been made by the writer.

COMMUNAL LIFE

Some species of Membracidae are decidedly gregarious in habit, and congregate not only as individuals of the same species but also with other species. This depends largely, but not altogether, on the host plant.

Thelia bimaculata and *Vanduzea arquata* are usually found together on locust; the individuals are inclined to crowd in dense groups, often with the bodies touching and in some cases even one upon another, specimens of both species being in close harmony. Each of these species shows the same gregarious habits when the other is not present. *Enchenopa binotata* found on the same host is prone to cluster together as individuals, but not to such a noticeable extent as the two other species, and they are seldom found living with other Membracidae. Most of the species of Ceresa, particularly *Ceresa diceros*, show the same habits; the adults are found in rows or groups on the stems and the nymphs are usually grouped. These species, however, seldom congregate with other forms of the family. In the same manner the Telamonas live together as individuals of a species but seldom as species of a genus or with other genera. *Entylia bactriana* and *Publilia concava* are decidedly gregarious and are found in dense clusters on their respective hosts. The two species have not been found living together, however, and this fact is additional evidence toward the proof that the forms are not so close together taxonomically as has been supposed. *Micrutalis calva*, while rare in this basin, has been reported as living the same communal life (Matausch, 1912 b), while most species of Stictocephala, Platycotis, and Vanduzea in this country are known to have like habits.

By this communal life is not meant any sort of division of labor, as is usually understood by the term as applied to certain Hymenoptera, but simply the habit of living together in colonies, the nymphs and the adults congregating in clusters or groups while feeding or resting (Plate XLIII, 1). So far as is known these habits have no significance beyond the mere indication of gregariousness. No actions have been observed which would tend to show that the individuals were mutually beneficial to one another in any way or that the community life affected in any manner the usual life history of the individual. It is interesting to note, however, that most of the species which lead such lives are attended by ants. It is easy to imagine that insects living in colonies may be more easily located by the ants than solitary species, but it is not believed that the ants have anything to do with the keeping of the individuals of the colony together.

It may be noted, also, that the individuals of certain species, such as *Ceresa bubalus*, live together as nymphs but separately as adults; this is no more than the natural result of the hatching of an egg mass and the subsequent scattering of the members. Other species are solitary and do

PLATE XLIII

1, Gregarious habits of *Glossonotus crataegi* Fitch
2, *Cerasa bubalus* Fabricius in position for leaping

(Photographs by H. H. Knight)

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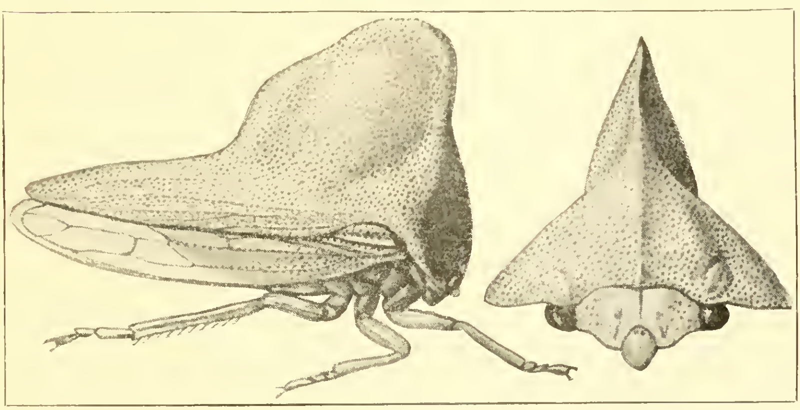
Plate XLIII

PLATE XLIV

1, *Telamona unicolor* Fitch
2, *Telamona collina* Walker

1



2

PLATE XLIV

not congregate as individuals nor mingle with other Membracidae. Such species are illustrated by *Campylenchia curvata, Archasia Belfragei, Smilia camelus,* and *Ophiderma pubescens.* This is not to be explained by the host plant or by the attendance or non-attendance of ants. *Archasia Belfragei* and *Smilia camelus,* for example, live on the locust, on which host *Vanduzea arquata* and *Thelia bimaculata* congregate in large numbers. It may be noted in the same connection that a greater number of species of Membracidae are found on the oak than on any other local host plant, and yet none of the species on this tree are given to communal life.

The species of the genus usually agree in showing a communal or a solitary life. A number of the species of certain genera are so rare locally, however, that this point has not been satisfactorily established.

In general the species of the basin seem to fall into five groups, as follows:

1. Species living with other species — *Thelia bimaculata* and *Vanduzea arquata.*
2. Species living together as individuals but not living with other species — *Entylia bactriana.*
3. Species living together as nymphs but not as adults — *Ceresa bubalus.*
4. Species living together as adults but not as nymphs — *Carynota mera.*
5. Species entirely solitary as both nymphs and adults — *Smilia camelus.*

ECOLOGY

Environmental conditions undoubtedly play an important part in the life history of the various species of Membracidae, and it seems very likely that when a sufficient amount of experimental data is available it will be found that many of the seeming irregularities in the periods of development which have been noted for the local forms may be explained by the variation in temperature and moisture to which the eggs and the nymphs are subjected. The experiments and observations made in the course of this study seem to show that seasonal variations in weather conditions, extremes of temperature for both long and short periods, moisture and humidity for the basin and for definite localities, and the physiological condition of the hosts used for oviposition and feeding, all have noticeable effects on the life of the species of this family. Detailed reports of the separate experiments and field records would be more or less alike and would necessitate unnecessary repetition, but type illustrations may be used which it is believed are representative of the main factors in ecology as noted.

For comparison of the results of variation in moisture the summers of 1913 and 1914 may serve as excellent extremes. The summer of 1913 was the occasion of the worst drought that has been experienced in this locality for many years. Vegetation suffered greatly and the United States Weather Bureau reported that all recent records were broken for lack of rainfall at the Ithaca station. The spring of 1914, on the other hand, was marked by unusual precipitation and the early part of the summer was very wet. The dates of hatching of the first eggs of *Vanduzea arquata* for these two seasons, together with the number of broods for the years, may be tabulated as follows:

Vanduzea arquata	1913	1914
Eggs hatched	May 15	April 26
Second-brood eggs laid	July 2	June 5
Third-brood eggs laid	September 16	July 18
Fourth-brood eggs laid	None	September 20

In the same seasons the variations in the nymphal periods of *Ceresa diceros* were as follows:

Ceresa diceros	1913	1914
First instar	5– 7 days	8–10 days
Second instar	5– 8	8– 9
Third instar	6– 7	7– 9
Fourth instar	9	10–12
Fifth instar	12–14	14–18
Total	37–45 days	47–58 days

From these figures it would appear that the hatching of the eggs and the development of the nymphs are retarded by dry weather and accelerated by abundance of moisture. As a natural result the number of broods is reduced in dry weather. This may be due to the condition of the vegetation during the favorable and unfavorable seasons, and it seems probable that the relationship between the insects and their hosts gives rise to complicated problems. In connection with the subject of moisture conditions it may be recalled that Ball (1915) has reported the fact that in arid regions *Vanduzea restita* Godg., *Campylenchia curvata* Fabr., and *Publilia modesta* Uhler have the habit of burrowing in the soil around the roots of the host plant as a protection against the sun and the dry air. In the Cayuga Lake Basin, where of course such conditions never prevail, the amount of moisture has no effect on the adult insect so far as has been observed.

It is not likely that excessively wet weather would greatly affect the eggs if temperature conditions were not adverse. The fact that the eggs are usually laid high up on the plants in buds and stems, where water would not remain, would preclude the possibility of their being drowned or injured by soaking.

Variations in temperature seem to have a like effect on the hatching of the eggs and the development of the nymphs. For data showing this variation the years 1914 and 1915 have been chosen as showing the widest extremes of temperature. The spring of 1914, besides being a season of much rainfall as already noted, was also warmer than usual; the same spring months of 1915, on the other hand, and in fact the entire summer of that year, were cold and disagreeable. The Weather Bureau reports show the following records for the months of May, June, July, and August, of 1914 and 1915:

AVERAGE MONTHLY TEMPERATURES

	May	June	July	August
1914	59°	66°	70°	69°
1915	52°	64°	69°	66°

The first records for these seasons, of nymphs and adults for a number of species, have been tabulated as follows:

Species	1914		1915	
	Nymphs	Adults	Nymphs	Adults
Enchenopa binotata	May 5	June 16	May 10	June 23
Ceresa diceros	May 17	July 29	May 20	August 2
Ceresa bubalus	May 12	July 2	May 10	June 30
Thelia bimaculata	June 1	July 6	June 3	July 10
Telamona ampelopsidis	June 2	July 10	June 2	July 14
Telamona unicolor	May 18	June 28	May 21	July 1
Cyrtolobus vau	May 29	July 13	June 4	July 20
Atymna castaneae	May 19	July 7	June 10	July 12
Ophiderma pubescens	June 4	August 1	May 28	July 25
Vanduzea arquata	April 26	May 16	May 2	June 1
Entylia bactriana	June 20	August 4	June 20	August 13

These figures show that only two species, *Ceresa bubalus* and *Ophiderma pubescens*, appeared earlier in 1915 than in 1914. Two others, *Telamona ampelopsidis* and *Entylia bactriana*, appeared on the same dates in both years, but each required a longer period for development in the colder season than in the warmer. The evidence is thus fairly conclusive that cold as well as dry weather is detrimental to the hatching of eggs.

Like results were obtained in the study of the length of nymphal instars. The record for *Thelia bimaculata* for 1914 and 1915 was as follows:

Thelia bimaculata	1914	1915
First instar	6– 7 days	6– 7 days
Second instar	5	6
Third instar	6	6
Fourth instar	6– 7	7
Fifth instar	7–12	9–16
Total	30–37 days	34–42 days

Since the year 1914 offered favorable conditions in moisture as well as in temperature, it is likely that the results obtained for that year were influenced by both conditions and it is of course impossible to determine the part played by moisture and temperature separately. The nearest approach to such a determination seems to be the comparison with records for some year in which normal conditions prevailed, which may be used as a check. The year that most nearly approached such conditions during the period embraced by this study was 1912. The average annual temperature for the basin, computed for a period of forty-one years since 1876,[6] has been found to be 47.2° F.; the average temperature for 1912 was 46°. The average annual precipitation for the same period was 33.44 inches; for 1912 the precipitation was 32.95 inches. Taking the year 1912 as a check, the field records show that the dates of first collection of the nymphs of the various species mentioned are very regularly between those of 1914 and 1915, while the length of the five instars of *Thelia bimaculata* averaged, respectively, 6, 5, 6, 6, and 12 days.

Variations in temperature seem to have little effect on the adults except that they appear more active in warm weather and remain later in the fall when the months of September, October, and November are warm. Many species have been collected in the field some time after the first few snows

[6] Monthly and annual meteorological summary and comparative data of Ithaca, N. Y. Weather Bureau Office, Ithaca, New York. December 31, 1916.

have fallen (Funkhouser, 1915 b:142 and 1915 f:185), and a number of forms may regularly be taken late in November even when the autumn has been cold.

The condition of the host plant is believed to have an influence on the life history of the membracid, but in most cases the conditions concerned have been of a general rather than of a specific nature. As a whole the Membracidae seem to prefer young plants to old ones, and favor twigs and stems not over two years of age. Saplings are more likely than old trees to harbor the insects, and the young shoots and buds of annuals rather than the main trunk. Often water sprouts at the base of a tree are covered with membracids while the tree itself is hardly molested; this has been noticed particularly in the cases of *Atymna castanea* and *Ceresa borealis*. Other observations made on this subject may be entirely accidental but should perhaps be mentioned. It has been noticed that oaks severely infected with galls were seldom chosen by Membracidae; that shrubs and vines on which aphids were numerous likewise were free from the insects of this family; but that, peculiarly enough, heads of goldenrod which were stunted or "stung" were most likely to have colonies of *Publilia concava* on them. In the last-named case it was thought that the membracids themselves might be responsible for the condition of the host, but there is no evidence to show that this is the case. Mr. Knight reports that in Batavia, where the species is common, he has noted the same tendency.

From the preceding field data it seems logical to conclude that moisture and warmth hasten the development of eggs and nymphs while opposite conditions retard such development. Collecting has shown that in general more membracids are taken on warm days than on cool days, and that the insects are more active during the hottest days of the season. It has already been noted that the Membracidae prefer sunny spots, open growth of foliage, and positions close to the ground.

It is evident, however, that the factors entering into the problems of ecology are so complex that no results can be accepted as proved unless all other factors than the one concerned have been eliminated, and this would be possible only by an elaborate series of studies extending over a great number of years. Naturally any influence that hastens or retards the hatching of eggs or the development of nymphs would advance or delay the dates for mating and oviposition. The variation in these dates

would of course affect the number of broods per season, and a variation in number of broods might in turn change all the dates for the following year. Thus the various phenomena in the life history of the insect are so closely bound together that the change of one condition may result in the upsetting of the entire structure of hypotheses in which this condition entered as a factor. It is not unreasonable to suppose that all the conditions that have been discussed, as well as many others on which no data have been obtained — such as sap conditions in the food plants, pathologic conditions in the insects themselves, and the like — enter into this complex ecology of which the foregoing can be considered as offering only the roughest suggestions.

ENEMIES

The Membracidae seem to have but few natural enemies and against these enemies the insects have a number of valuable methods of protection. The field notes show surprisingly few cases in which membracids have actually been seen taken by other animals or killed by natural foes.

PARASITES

Parasites are found on both eggs and adults. The egg parasites are common on the eggs of most species of the genera Ceresa, Stictocephala, Telamona, and Vanduzea. These in most cases are Chalcididae and only a few have been determined. A detailed study of this egg parasitism which has been made by the writer for an African species, *Oxyrhachis tarandus*, and which is to appear as a separate report, as well as observations on local forms from which the parasites were reared, seems to show that the method is the same in all cases. The parasite deposits its egg in the newly laid eggs of the membracid and passes its larval and pupal stages within the egg. On maturing, the adult hymenopteran emerges by breaking open the cap of the eggshell, which has meanwhile become discolored or blackened. The oviposition of the chalcid has not been observed for any of the local species, but parasitized eggs have been found from which the parasites have been reared. The only parasite thus reared locally has been *Polynema striaticorne* Gir. Miss Murtfeldt (1890) credits an undescribed Polynema with having destroyed membracid eggs in Missouri, and Hodgkiss (1910:91) states on the authority of Girault that the species in question was the same species and that it has been bred from eggs of *Ceresa bubalus* at Geneva. Apparently this is a common and

widely distributed hymenopterous parasite of membracid eggs. Jack (1886 b) reports egg parasites from this species of membracid, and Ashmead (1888: 107) has described a new species, *Trichogramma ceresarum* Ashm., from the same host. An egg parasite of *Vanduzea arquata* has been recorded (Funkhouser, 1915 f), but has not been reared.

Parasites in nymphs and adults are very common but have never been successfully reared. Larvae that were apparently hymenopterous have been found in the abdomens of insects of various species of Telamona, in *Ceresa borealis*, *Carynota mera*, *Cyrtolobus vau*, and *Thelia bimaculata*, but all attempts to bring the parasites to maturity have thus far proved failures. It is now believed that more than one season may be required to complete the life history of the parasites and that previous failures may be due to the fact that sufficient time was not allowed for such development. Matausch (1911) has reported similar parasitism in species of the genera Telamona, Carynota, Thelia, and Glossonotus, which he believes is responsible for the destruction of the sexual organs; but he was equally unsuccessful in rearing a single specimen of any of the parasites, altho he presents an excellent figure of the larvae. Apparently there is some phase of the life history of these parasites which does not lend itself to the usual methods of rearing. Dr. S. I. Kornhauser, of Northwestern University, reports, however, in correspondence, that he has been successful in rearing the parasites of *Thelia bimaculata*, and states that they are Dryinidae of the genus Aphelopus.

A small red mite occasionally appears as an external parasite on *Telamona ampelopsidis* and *Thelia bimaculata*, and Wildermuth (1915: 359) reports a similar mite (*Erythraeus* sp.) feeding on the eggs of *Stictocephala festina* in the Southwest.

BIRDS

Very few of the local species are molested by birds. A few species of birds have been observed feeding on the nymphs but usually neglecting the adults, the latter being probably sufficiently protected from bird enemies by the hard pronotum and sharp processes. Various species of adult membracids have been thrown to birds in captivity; in general these have been refused but in a few cases they have been picked up only to be dropped again. Evidently the strong pronotal processes, which are often sharp and hard enough to pierce the skin if the insect is seized

suddenly, are unpalatable and irritating. The only birds that have been actually observed eating membracids, with the species and form indicated, are as follows:

Bird	Nymph	Adult
Chipping sparrow	*Vanduzea arquata*	
Song sparrow	*Entylia bactriana*	*Entylia bactriana*
Catbird	*Telamona unicolor*	
Oriole	*Ceresa taurina*	
Warbler (various species)		*Vanduzea arquata*
Redstart		*Ophiderma pubescens*
Bobolink	*Stictocephala inermis*	
Bluebird	*Telamona ampelopsidis*	
Thrush (various species)	*Atymna castaneae*	*Atymna castaneae* (?)

While this list is sufficiently imposing as it stands, it must be remembered that the instances are in every case single ones and are the only observations obtained during a long period of collecting. The truth is that, so far as the data of the basin show, the birds are of little importance as membracid enemies.

Records from other parts of the country seem to indicate that birds are far more of a factor in this respect than is the case locally. Wildermuth (1915) reports that of thirty-one birds, representing eight different species, ten had from one to four adults of *Stictocephala festina* in their crops; and W. L. McAtee (recorded in correspondence) has taken the rare species *Idioderma virescens* VanD. from the stomach of a nighthawk.

OTHER ENEMIES

One instance has been noted of a toad industriously engaged in trying to take nymphs of *Thelia bimaculata* from the base of the trunk of a locust sapling. The operation seemed to be fraught with some difficulty because of the tenacity with which the membracids held to their host and because of their sheltered position in the cracks of the bark; they would doubtless have escaped unnoticed had it not been for the movements of the large ants running briskly about them. Two cases are recorded of toads feeding on both nymphs and adults of *Entylia bactriana*.

The asilids commonly carry off both nymphs and adults. This has been noted particularly in the cases of *Atymna castaneae*, *Carynota mera*, *Thelia bimaculata*, *Vanduzea arquata*, and *Telamona unicolor*. In only one case, however, was it possible to capture the asilid, in which instance it proved to be *Erax bastardii* Macq. There is no question that several species of this fly prey on Membracidae.

Spiders often capture membracids both in their webs and on twigs. An undetermined species of spider has been observed to seize adult specimens of *Vanduzea arquata* on the limb of a tree and spin a web around the body until the insect was inclosed in a cocoon-like mass, after which it was carried away; in these instances the membracids did not appear to have been bitten by the spider, at least not to such an extent as to cause paralysis, for the legs could be seen moving and the body struggling after incasement in the web — the hard pronotum probably serving here again as an excellent protection. Many cases are recorded in the field notes of spiders carrying away membracids, of membracids caught in the webs, and of their empty skeletons found in the spiders' retreats. Most of the common species of Membracidae are so listed but opportunity has not offered for the determination of the spiders concerned. Professor R. W. Harned, of Mississippi Agricultural College, has sent the writer a spider which he captured at Lake View, Mississippi, eating a specimen of *Vanduzea arquata*; this has been determined by Miss Anna Stryke as *Marxia* (*Plectana*) *stellata* var. *nobilis*.

One instance has been noted of a mantis (*Paratenodera sinensis* Sauss.) feeding on a nymph of *Vanduzea arquata*, and two cases of the same insect capturing adults of *Atymna castaneae*.

Assassin bugs (*Reduvius* sp.) have often been observed in the vicinity of colonies of Membracidae, but no actual instances have been recorded of their attacking such colonies.

PROTECTION

Considering the small number of their enemies, the Membracidae are remarkably well protected and their methods of protection are unusually varied.

The shapes and colors of both nymphs and adults of most species tend toward very effective concealment. Browns, greens, and grays in neutral tones predominate in the color scheme of the family, and these tones

blend with those of the leaves and bark of the host plants to an extent which offers excellent protection. The shapes, even of the local forms which are of course far less bizarre than the grotesque exotic species, are of an interesting variety and present opportunities for a wide range of surmises. It has been noted in the discussion of the pronotal anatomy (page 312) that many explanations have been offered for the unusual structures shown in the exoskeleton of this family, and that the theories both of natural selection and of orthogenesis may be well illustrated by certain forms of Membracidae. An elaboration of this subject would be out of place in a study limited to the forms of the Cayuga Lake Basin, since for an appreciation of the subject the entire family must be taken into consideration. Nevertheless it may be pertinent to call attention to a few of the local species which offer rather peculiar features apparently adapted for imitation or protection.

It has been remarked that the nymphs of *Thelia bimaculata* and *Vanduzea arquata* are almost indistinguishable when at rest in cracks of bark. This is due not only to their color but also to the dorsal protuberances, which closely resemble the irregularities of the plant. An even more striking instance is offered by the nymphs of *Enchenopa binotata*, the dorsal spines of which are wonderfully like the tiny unfolding leaves of the locust which are contemporary with them, even the light green color being common to both. In the mature insect the adult of *Thelia bimaculata* shows a pronotal projection which is easily mistaken for the thorns of the host plant, and in the adult of *Enchenopa binotata* the pronotal horn in the same manner imitates the spines and stipules of the locust. This certainly seems to be an adaptation which may be accounted for by natural selection. Poulton (1903:277) has called attention to the fact that it is hard to deny the theory of protective resemblance when the same object is accomplished by both the nymph and the adult but in different ways. In the case of the local forms mentioned above, the nymph imitates the uncurling leaf or the irregular bark by spines on both thorax and abdomen — chiefly the latter — while the adult imitates an entirely different part of the plant by the development of an entirely different part of the body. On the other hand, some of the commonest of the local species of Membracidae in no respect seem to resemble any part of the host on which they live, altho their shapes are decidedly peculiar. The high dorsal crest of the Telamonas, for example, can only by a stretch

of the imagination be made to resemble any peculiarity of the oak twig on which the insects rest, and in fact they are very conspicuous on their host. Likewise the Ceresas, perhaps the most widely distributed genus in the basin, are plainly seen when in their natural surroundings, and the two prominent suprahumeral horns do not in the least resemble plant structures with which the insects are associated. The answer of the natural selectionist might be that at some previous time such adaptation had held, and this of course is unanswerable since we have no way of knowing what host plants may have been the home of the insects in bygone periods; but it is interesting to note that the genera Ceresa and Telamona, which now show little protective resemblance to parts of their hosts, are more numerous and apparently maintain an existence with greater ease than do those species that show very excellent protective resemblances.

It is unnecessary to take up separately each of the local forms in this respect. For each it is possible to suggest an explanation, reasonable or otherwise according to the degree of imagination possessed. But in general it must be said for the local forms, as for the family as a whole, that such speculation merely lies in the realm of conjecture.

The habits of the Membracidae afford a protection by no means unimportant. The fact that they remain motionless for hours at a time, pressed tightly into the axil of a leaf or the crotch of a twig, may explain their escape from many enemies. Their habit also of remaining quiet during that part of the day in which the birds are alert, and confining their activities to the hottest parts of the day when other animals are inclined to be at rest, has been suggested as tending toward their protection. The habits of both nymphs and adults of creeping around to the other side of a branch when approached is no doubt purely protective.

A most valuable and effective method of protection is the insect's quick flight when disturbed. The sharp spring from the twig followed by the erratic course thru the air is decidedly deceiving to the eye and is doubtless an efficient defense against the attack of any but the most active and keen-eyed enemies. In fact no enemy has been observed to capture a membracid while the latter was on the wing.

Finally, the hard pronotum and sharp spines of the thorax are doubtless sufficient protection against most foes. Very little of the soft parts of the membracid's body is exposed, and the tough, often hairy prothorax

may be presumed to be far from tempting as a morsel of food. Moreover the sharp, hard spines which in many species project in many directions may deter the captor from swallowing the membracid even if captured. It should be remembered that besides the frontal horns possessed by many membracids, and the rough humeral angles possessed by most, the posterior process usually projects in a very sharp spine and is in some cases capable of inflicting a wound of no mean proportions.

Thus the shape, color, habits, ability to hide, power of flight, and skeletal armor are all to be included in the list of methods of protection — a list sufficiently long and varied to give satisfactory results.

ECONOMIC IMPORTANCE

As a family, the Membracidae are not to be considered as of great economic importance in the Cayuga Lake Basin. Even the three or four species that have been credited with destructiveness in other parts of the country and that are here represented are of no particular importance locally so far as damage to host plants is concerned.

The manner in which membracids have been known to cause damage is limited to two habits, feeding and oviposition. Of these the latter is the more harmful.

So far as feeding is concerned there is little evidence that Membracidae cause any injury to the host, either locally or otherwise. The quantity of sap consumed by the insects is negligible, and the wounds made by the incisions of their beaks are neither large enough to destroy tissue nor extensive enough to offer opportunity for infection. In fact such incisions cannot usually be found even with a microscope a few hours after the process. Trees that are literally covered with Membracidae seem in no way less healthy than those on which no insects are present. Careful examination of trees in the field show absolutely no indication of injury from feeding habits.

The egg-laying process may be more destructive, but even this process is of no local concern. In most cases the slit made by the ovipositor is clean and sharp and very superficial, seldom extending to the cambium and usually healing at once without a scar. The phloem tissue if injured is not so extensively damaged as to interfere with its function, and the injured part, in dicotyledons at least, would usually slough off naturally within the first or the second season. The ovipositor in most of the

species is neither long nor powerful, and in those forms in which the eggs are laid in the stems of trees — which include the larger number of species — the organ either does not reach to the xylem or, reaching it, is not able to penetrate the harder wood and slips to one side, leaving the eggs between the wood and the bark. In the cases in which the eggs are laid in buds, the part of the bud chosen is usually the outer scales, which are not thereby prevented from performing their functions as protective organs and are of little importance in the later development of the plant.

Fig. 43. twigs injured by oviposition of ceresa bubalus
Photograph by H. H. Knight

A few exceptions to these general conclusions may be noted. The species which has attracted the most attention from an economic standpoint and which is oftenest mentioned in literature as destructive to trees, is *Ceresa bubalus*. This species is peculiar in that it lays its eggs in curving, nearly parallel rows, in such a fashion that a definite area is cut out of the bark, which fails to heal and leaves a conspicuous line of scars (fig. 43). These scars persist for several years and are occasionally infected with fungi and offer an entrance for other insects. The first record of such injury seems to have been made by Marlatt (1887), and is followed by a detailed account, with excellent figures, by the same author (1894). Since that time a long series of references to the scars, particularly on apple trees, has appeared. Hodgkiss (1910) worked out the life history of the species on apple and pear, and credits it with doing considerable damage to the twigs (page 97 of reference cited). The species is very abundant in orchards in the vicinity of Ithaca, particularly in Hook's orchard on

West Hill and in Gilkey's orchard near by. An examination of the trees in these orchards shows plenty of the characteristic scars, but no cases have been found in which the trees seem to be seriously affected beyond the unsightly appearance of the twigs. Only one case of infection has been found. The species is very abundant locally also on young elms, on which the same unsightly wounds may be found. Here again, however, the trees seem in no way weakened by the presence of the insect.

Ceresa borealis likewise makes deep wounds which leave ugly scars on the twigs. This species is found on a large number of hosts and the scars are so characteristic that they are easily recognized. As in the case of *Ceresa bubalus*, attempts to show serious injury to the plants by this species have yielded little result.

It must be admitted that if such punctures are made in very young twigs or in the soft stems of annuals, especially if made close enough together to girdle the stems, the results will be very serious. This has been shown to be the habit of *Stictocephala festina* in the South (Wildermuth, 1915:357), and is known to be true of certain other southern and western forms (Jack, 1886 b, and Osborn, 1911). In this basin, however, there are so few forms which have this habit that the amount of injury is of no importance.

A far more serious type of injury is done by those species that lay their eggs in the buds, particularly if the buds happen to be small ones in which the internal tissues can be reached. *Ceresa taurina* and *Stictocephala inermis* both deposit their eggs in the buds of fruit trees. In most cases the buds chosen are large terminal buds and the eggs are so lightly inserted that they may be seen projecting on the outside of the buds. In these cases very little damage can result. In a few instances, however, the buds chosen have been so small and the eggs so deeply inserted that the buds have been deformed. In the case of a fruit bud this would of course result in economic loss, but the chances are so largely in favor of the choice of large buds, or of leaf buds which can be replaced without serious results, that the relative injury done is small.

The most serious damage to buds has been observed in the case of *Enchenopa binotata* on butternut (Funkhouser, 1915 c). Here the buds are not large, and the eggs are inserted so deeply and in such large numbers that the buds are occasionally entirely destroyed. The same insect has been reported as doing serious damage to other plants in various parts of

the country (Fitch, 1851; Riley, 1880; Comstock, 1888; Packard, 1890; Saunders, 1904:242–243), and may probably be considered as the most important of the local Membracidae so far as injurious habits are concerned.

On the whole it is believed that the importance of the Membracidae as injurious insects has been exaggerated. The fact that many species of the family are very abundant locally and very little injury to hosts can be attributed to their activities, would seem to indicate that in this basin their economic importance may be discounted. This may of course be due to the fact that the combination of favorable crop and injurious species is not represented in the basin and does not discredit the reports from other localities.

CONTROL

Because of the fact that the Membracidae have not been considered as a pest in the basin, no control measures have been tried. With our present knowledge of the family, however, a number of methods suggest themselves as efficacious in case the insects should become destructive.

Since most of the species that might prove harmful are dependent on succulent weeds for nourishment during the nymphal stages, the removal of such weeds from the vicinity of the host infected would destroy the food plants necessary for their development.

The egg masses of the species concerned are easily located and the scars are sufficiently characteristic to insure instant recognition. Such egg masses are usually found on comparatively young stems, and could be removed by intelligent pruning and then destroyed.

The nymphs of all species are very soft-bodied and habitually rest in the crotches of twigs and the axils of leaves, where they could be easily reached by contact sprays. Liquid sprays of the miscible oil or nicotine type would run down the twigs and collect in such places, even if applied in a very careless and superficial manner to the tree.

Very few if any of the forms of the Homoptera are so poorly adapted by habits and like factors to resist the ordinary control measures of the entomologist, as are the tree-inhabiting species of the Membracidae, and it seems hardly likely that in orchards or forests in which the simplest kind of preventive work is done they will ever become a serious pest.

On small crops the problem would be more complex, since the use of contact sprays might not be advisable and the egg masses not easily taken. Even in such cases, however, the insects would doubtless depend

on other hosts in which to lay the winter eggs, and if such hosts were not available they would probably not be able to winter over. In such cases, also, the membracids would probably yield as readily to the various types of hopperdozers as do most of the other grass- and grain-inhabiting insects.

The suggestions, then, for the control of the species of this family if they should become numerous enough and destructive enough to be considered as pests, would be, first, clean cultivation. In this work particular attention should be paid to leguminous weeds, such as sweet clover and alfalfa, in fence corners and around orchards. Secondly, careful pruning should destroy most of the egg masses. Thirdly, the use of contact sprays should kill the insects in the nymphal stages.

It is admitted that in the course of this study the main idea has been to preserve the membracids of the basin rather than to destroy them, and the above suggestions are entirely theoretical.

BREEDING EXPERIMENTS

Breeding experiments have been carried on both in the field and in the insectary.

In the field the most satisfactory method has been to cover an egg mass with fine netting and make regular observations during the period of development, taking such specimens from time to time as were necessary to show each of the instars. The eggs were usually located in the winter or early in the spring, and a large piece of the branch or twig was covered with netting — generally bolting cloth, but in some cases cheesecloth — in such a fashion as to prevent the escape of any of the insects and at the same time allow them a wide range of movement in their natural environment with natural sap conditions. The method had the additional advantage of preventing other insects, and particularly other specimens of membracids from neighboring colonies, from mingling with the brood studied. Practically all the species in the basin whose life histories have been worked out were reared in this manner. From such experiments valuable data have been obtained regarding the variation in nymphal periods of individuals from the same egg mass, as recorded in preceding paragraphs for a number of the species.

In a number of cases the host plants, with egg masses or colonies of nymphs, have been transplanted to the writer's garden for more con-

venient observation. This has proved very desirable in the case of thistles bearing *Entylia bactriana* and sweet clover infested with nymphs of *Stictocephala inermis* and various species of the genus Ceresa. In such instances only one plant of the host was brought into the garden, and it was not found necessary to cover the plants since with no other food plant in the vicinity the insects showed no inclination to migrate. The same method was used in rearing *Publilia concava*, which is rare in the basin but commonly found in other parts of the State on goldenrod. Small plants of goldenrod were transplanted from fields and roadsides, and on them were placed nymphs sent from Batavia, New York, by H. H. Knight. In this manner all the life history data were obtained with the exception of the oviposition and the first two instars.

In connection with the work on this species experiments were made to determine the validity of the theory that *Publilia concava* and *Entylia bactriana* were synonyms or varieties of the same species. Specimens of Publilia were placed on the thistle alone and with individuals of Entylia; specimens of Entylia were placed on the goldenrod alone and with individuals of Publilia; certain colonies in each case were inclosed, while others were allowed to change hosts at will. Careful observations were made on habits and behavior, especially with reference to mating and to the mingling of the forms. The results of these experiments will be the subject of a special report, but it may be mentioned here that no evidence has been found to show from a biological standpoint that the species are not distinct.

In the majority of cases, colonies inclosed in the field were visited at least every third day and sometimes oftener. In this manner fairly accurate data were obtained as to the progress of development. Notebook records were kept containing the observations of each visit and these records have been used as the basis for this study. Such field work was made possible by the fact that colonies of most of the species could be located in stations close to Ithaca, and regular routes worked out by means of which all could be visited.

Indoor breeding experiments fell into three groups: the hatching of eggs from buds and twigs brought into the laboratory in early spring; the rearing of nymphs on host plants that could be grown in the insectary; and the observation of adults on food that could be maintained in a fresh condition in the insectary.

In the first method, buds and small twigs containing egg masses were brought into the warm laboratory and placed in wide-mouthed bottles filled with water and plugged with cotton, the whole being covered with a lamp chimney topped with cheesecloth. In such cases the buds opened or the twigs were forced, hastening the hatching of the eggs and making possible the securing of the first and second instars. This practice also permitted the study of the escape of the insect from the egg and the collection of egg parasites if present. In most instances, however, the nymphs died after the first or the second molt, either because of the unnatural sap conditions of the twig, because they did not survive removal to fresh twigs, or because a different host was required for feeding from that on which they were hatched. The method was entirely satisfactory for the purposes for which it was conducted, and most of the early instars have been obtained in this fashion.

For the rearing of nymphs thru all their instars it was necessary to have young plants in the insectary. Unfortunately many of the species live only on trees, which could not be maintained in the limited quarters available for experimental work. In some cases a constant supply of fresh twigs and leaves were sufficient to keep the nymphs alive, but the method was not satisfactory. Fortunately, however, a number of the species spend the nymphal periods on small plants, which could be grown in the greenhouse. Sweet clover, alfalfa, joe-pye weed, thistle, goldenrod, aster, daisy, and clover were successfully potted and kept under bell jars, and on these hosts various species were brought thru to maturity. By this method it was possible to observe the process of molting and to get the cast skins after each molt. These cast skins proved to be of some value in making measurements. The chief difficulty experienced in this method was that of maintaining satisfactory temperature and moisture conditions. Under the greenhouse glass the heat often proved too severe for the nymphs, and the plants if neglected even for a short period were likely to wither. However, with constant care the nymphs of a number of species may be reared successfully, but it is a question whether the time records for the various molts are reliable since the conditions are undoubtedly different from those in the field. For this reason such records have been used merely as a check on the field records whenever the latter were available.

Adults brought into the insectary for observation thrive very well on twigs and branches of their usual host plants if the latter was renewed from time to time. The twigs are put in open jars containing plenty of water, the insects are put on the twigs, and a large bell jar, covered with netting only at the top, is placed over the whole. At first the insects are inclined to be restless and fly against the sides of the jar in their efforts to escape. Soon, however, they become quiet and settle down on the twigs. After a few days, during which their efforts to fly thru the glass have proved fruitless, the insects apparently become reconciled to their prison and the bell jar may be removed for hours at a time, the insects not realizing that the glass is not between them and liberty. Under such conditions the processes of feeding, mating, and oviposition may be observed at close range and very satisfactory results obtained. Practically all the commoner species of the basin have been thus confined and their habits noted.

On the whole, breeding experiments in the field have proved more satisfactory than those conducted in the insectary. Certainly they are far more easily made and the results are more indicative of the natural life of the insect studied.

METHODS OF COLLECTING

The methods of collecting Membracidae vary with the species desired and no general method is applicable to all forms. The four methods most commonly used locally have been sweeping, beating, using trap lanterns, and taking the insects by hand. Of these the last has been the most satisfactory.

A few of the local species — namely, *Campylenchia latipes*, *Stictocephala lutea*, *Stictocephala inermis*, *Ceresa bubalus*, *Ceresa taurina*, *Ceresa borealis*, *Entylia bactriana*, *Publilia concava*, and occasionally *Enchenopa binotata* — are taken by sweeping in pastures, along roadsides, in meadows, and among the weeds in and around orchards. The nymphs as well as the adults may be thus taken, and in the case of *Campylenchia latipes* sweeping has been found the most satisfactory method of collecting. For most of the forms, however, it is not productive of the best results, due to the fact that the insects often cling very tightly to their hosts when disturbed, and the hosts at the time when the insects are most numerous are not easily swept. For example, sweet clover, alfalfa, buckwheat,

clover, and most of the common weeds on which membracids are found, are in full bloom or early fruit at the time when the insects are abundant; at this time sweeping is very difficult owing to the fragile condition of the flower heads and seed pods, which accumulate in the net to such an extent as to make the sorting of the catch most laborious. Moreover, at this season the above-mentioned plants are visited by countless numbers of bees, which do not welcome the presence of the collector and which make the vigorous sweeping of the plants a most unpleasant operation.

The use of the net in trees is usually out of the question. Not only do the branches interfere with the sweep of the net, but in many cases the hosts are thorny plants which quickly tear a net to pieces. This is particularly true of locust trees, berry bushes, rosebushes, hawthorns, and wild crabs, on which many species are prevalent.

Beating has not proved a satisfactory method of collecting, altho in a few cases good catches have been made by the use of a stout club and a collecting umbrella. In most cases the membracids either cling too tightly to the host to be dislodged, or else take flight instead of dropping to the ground as in the case of many Hemiptera. In practically all cases the insect leaves the branch with a quick spring when disturbed or when the plant is jarred, and makes a short flight to a neighboring branch. Many attempts to collect in this way have resulted in the abandonment of the method.

Trap lanterns have been used with little success. Apparently few membracids fly well enough or far enough to be taken in this manner, or else the insects are not attracted toward the light to as great an extent as are other insects. The only species taken with a trap lantern in the basin have been *Atymna castaneae*, *Cyrtolobus vau*, *Ophiderma pubescens*, and *Campylenchia latipes*, and these have been so taken only in rare instances.

By far the most satisfactory method of collecting Membracidae is that which may be termed *hand picking*. After a little experience it is not difficult to see the insect on the plant, especially after the habits of the various species have been learned. They may be approached without suspicion if care is taken to make the movements of the hand slow and regular. When the hand is within a few inches of the insect a quick grab secures the specimen. After a little practice individuals

crowded close together on a branch may be picked off one by one without disturbing the others. It has been found best to approach the individual directly from the front, so that if its spring is made suddenly the insect will leap into the hand rather than away from it; in practically every case the insect leaps straight ahead when disturbed. This method has the additional advantage of always yielding a perfect specimen, since there is little chance of injury in the process. Moreover, the insect in the fingers may be easily transferred to the cyanide bottle without loss of time or opportunity for escape. The fact that Membracidae are harmless, cannot bite nor sting, and have none of the disagreeable odors common to so many of the Hemiptera, is an added advantage for this method of collecting. Moreover the natural joy of discovering and stalking a rare specimen and the satisfaction of making the capture without mechanical aid is an added inducement to the true hunter. But the greatest advantage of this method is the opportunity given to observe the habits of the insects in the field, whether or not the specimen is captured. It is a temptation at first to take the specimen at once, without waiting to note its actions; but if this inclination to seize the insect at once is overcome, the subsequent pleasure and profit in observing the life habits well repays the time spent.

No particular time of day has been found especially favorable for collecting, but, since the insects are most active during the hottest parts of the day, they are more easily seen and more of their habits are observable during those hours in which the temperature is highest.

The adults collected were usually placed directly in the cyanide bottle, and could be easily carried without danger of injury since their hard bodies and well-covered or closely folded wings prevented their mutilation by being jarred or shaken together.

Nymphs were placed in vials of 70-per-cent alcohol, of which a supply was always carried. If possible all nymphs of a single species, with their attendant ants, were placed in the same vial.

Eggs and egg masses, with the twigs or the leaves containing them, were placed in vials of 30-per-cent alcohol, and were removed from these to other containers on the return to the laboratory.

Adults or nymphs that were to be kept alive were placed in large, wide-mouthed vials together with bits of the food plant, and the necks of the vials were loosely plugged with cotton.

METHODS OF PRESERVING

For the permanent collection, adults were invariably pinned and nymphs were preserved in 70-per-cent alcohol. In some cases the nymphs of the last instar were preserved in both ways, some in alcohol and some on pins.

No special directions need be observed in pinning the local forms of the family, but in the preparation of exotic material in which characters are found in the trochanters it is very necessary to pin the specimen in such a manner that these appendages will not be destroyed.

The principal characters necessary for the recognition of the local forms are found on the head, the dorsal crest, and the wings. If, therefore, the pin is placed directly downward thru the prothorax on one side of the median dorsal line, it will usually not interfere with the structures needed for diagnosis. It has been found very convenient to mount a few individuals in each series with their wings spread out or at least removed from beneath the margin of the pronotum, since in a number of genera the cells of both the fore and the hind wings are used in systematic work.

The use of points is not to be advised in mounting Membracidae, since if the insects are securely glued to the point the abdomen and the femora, and even the beak, are likely to be hidden, and, as has been noted, these structures are often valuable in making determinations.

Species that are too small to be easily mounted on regular pins may be satisfactorily mounted on *minuten nadeln*, which have all the advantages of points without the disadvantage of obscuring any part of the body.

Individuals taken in copula are mounted on the same pin if large and on two *nadeln* on the same pin if small.

Date, locality, and host labels are placed on each pin if the data are available and the insect is intended for the permanent collection. No record has been kept of the particular station where the specimen was taken except in the field notes, and this record is not attached to individual specimens.

Nymphs may be kept indefinitely in 70-per-cent alcohol. The last two instars may be mounted on pins and preserved in fairly good shape, altho they are likely to dry out and are unreliable for use in making comparative measurements.

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